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SEASONAL INCIDENCE AND POPULATION OF BLACK ICTRUS APHID *TOXOPTERA AURANTII* (B. de F.) ON COORG MANDARIN

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(Received 1 December 1984

Population dynamics studies were conducted on black citrus aphid, *Toxoptera auranti* (B. de F.) at the Central Horticultural Experiment Station. Chethalli, Kodagu during 1981 to 1983 which revealed that though the aphid was active throughout the year the highest population peak was observed during June 3rd to July 1st week with nine overlapping generations in a year. Temperature range of 22 to 27°C was congenial for aphid multiplication. The best time for application of the insecticidal spray to control the aphid would be during May last week and June 2nd week.

(Key words: Toxoptera aurantii, seasonal population, Coorg mandarin)

INTRODUCTION

Toxoptera aurantii (B. de F.), the black citrus aphid occupies an important position among the various sucking insect pests of citrus which cause citrus decline in India (CAPOOR & RAO, 1967). The aphid infestation causes severe curling and deformation of young leaves resulting in stunted growth of the twigs (BINDRA, 1970). Premature falling of fruits and reduction in their quality also are caused (NAIR, 1975). The insect is also a vector of 'tristiza' virus (CAPOOR & RAO, 1967).

Results of studies made on the seasonal occurrence and population of the aphid on ***Coorg mandarin*** orange in Coorg are presented in this paper.

MATERIALS AND METHODS

Seasonal incidence and population fluctuation of the aphid was studied at the Central Horticultural Experiment Station, Chethalli, Kodagu, Karnataka from January 1981 to December 1983. These studies were made on 20 randomly selected plants. Incidence of the aphid was assessed once in a week on 10 randomly selected tender flushes on each plant by counting the total number of nymphs and adults on each flush. The extent of infestation of the aphid was computed and expressed n three ways as given below based on average aphid counts of three years.

a) *Percentage incidence :* $\frac{\text{total infested flushes}}{\text{total number of flushes observed}} \times 100$

b) *Aphid incidence index:* For computing this, the flushes were graded based on the presence of total number of aphids as follows :

Contribution No. 140/84 of Indian Institute of Horticultural Research, 255 Upper Palace Orchards, Sadashivanagar, Post Box No. 8025, Bangalore-560 080.

grade value	*number of aphids / flush*
0	no aphid
1	1— 30
2	31— 75
3	76—150
4	above 150

$$\textit{Aphid incidence index} = \frac{\text{frequency in each grade} \times \text{grade value}}{\text{total number of flushes} \times \text{value of higest grade}} \times 100$$

c) Mean number of aphids/flush. The total number of aphids on all the flushes were added and averaged per flush.

Meteorological data for the entire period has been averaged and depicted in Fig. 2.

RESULTS AND DISCUSSION

All the three methods of representing the population fluctuations of the aphid showed the same trend (Fig. 1). The aphid infestation was present on the plants throughout the year. The highest population peak of the aphid was noticed between June 3rd week and July 1st week with eight medium population peaks during January 1st week, Feburary last week, April 1st and 3rd weeks, August last week and October 3rd week, November 3rd week and December 2nd week. SETHI & JAWANDA (1965) reported that *T. aurantii* remained active from December to March, as different during June–July observed in the present studies.

The highest population of aphid was recorded during June–July when the maximum temperature was very low, below 27°C and minimum temperature was high, above 22°C. The rains received in the first fortnight of June induced water sucker and the initial population

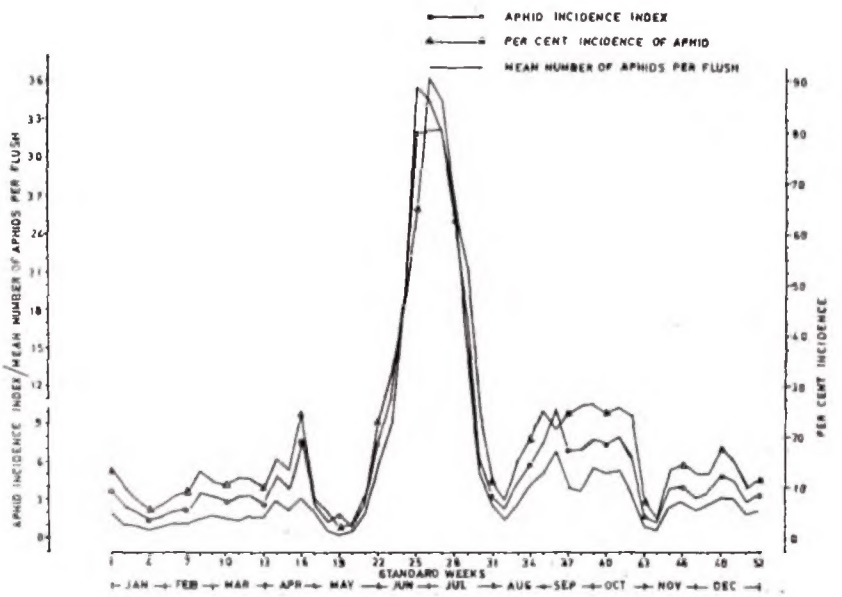

Fig. 1. Seasonal incidence of black citrus aphid, *Toxoptera aurantii* (B. de F.) on *Coorg mandarin*.

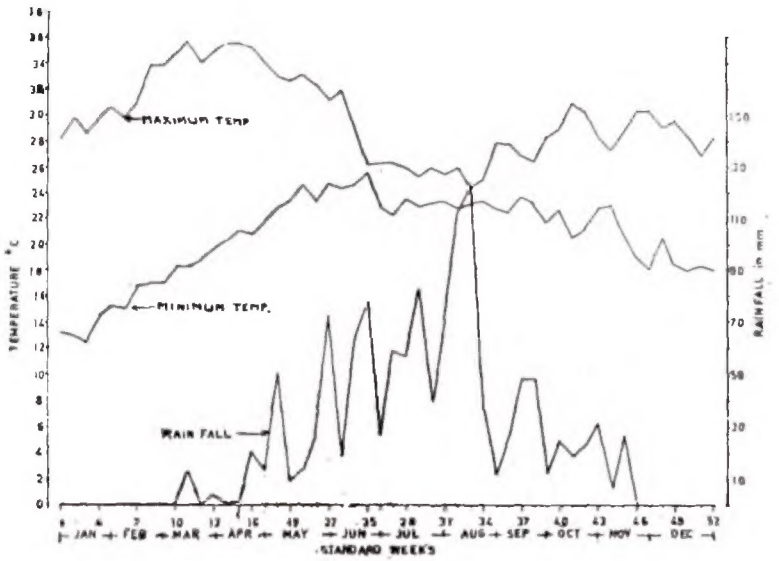

Fig. 2. Meteorological data.

of aphid multiplied on these water suckers before migrating, settling and multiplying on tender flushes in the latter part of June and first fortnight of July.

The results presented indicate that synchronizing the spray schedule at the time of highest aphid population peak can keep the aphid population at a lower level of infestation during the remaining periods of the year. Spraying twice with systemic insecticide in May last week and June second week appears to be effective in preventing the aphid multiplication on citrus under Kodagu conditions.

Acknowledgements: The authors are grateful to the Director, Indian Institute of Horticultural Research, Bangalore for constant encouragement and facilities provided and to Mr. K. B. KARIAPPA and Miss. M. K. PADMAVATHY for their technical help in collecting the observations.

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INFLUENCE OF *ANERISTUS CEROPLASTAE* HOWARD (HYMENOPTERA : APHELINIDAE) ON THE POPULATION OF *PULVINARIA* SP. (HOMOPTERA : COCCIDAE)

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(Received 19 October 1984)

A comparative study of the population trend of healthy, dead (due to adverse climatic conditions) and parasitized coccid, *Pulvinaria* sp. was carried out for seven consecutive generations in a period of one year. The result showed that the parasite *Aneristus ceroplastae* was always able to bring down the population of the coccid to near basal level in about two to three weeks time, and hence can be considered as a potential biological control agent for *Pulvinaria* sp.

(Key words: Pulvinaria sp., *Aneristus ceroplastae*, parasitism)

INTRODUCTION

In India, *Pulvinaria* spp. have been reported to infest several economically important plants (ALI, 1968; NAYAR *et al.*, 1976). Dr. D. J. WILLIAMS, the coccidiologist at the Commonwealth Institute of Entomology, London who identified our specimen wrote in a personal communication to the author that there was great confusion regarding different species of *Pulvinaria* and perhaps different names are being used as synonyms, hence our specimen should be designated only as *Pulvinaria* sp. In Dec. 1982, this particular species was noticed on chili *(Capsicum* sp.) and primrose *(Mirabilis jelapa)* at Bhagalpur, and subsequently was found to be parasitized by *Aneristus ceroplastae*. The latter has also been reported to parasitize several coccid species viz. *Ceroplastes floridensis* Comst., *Chloropulvinaria polygonata* (Ckll.), *Coccus hesperidum* L., *Pulvinaria* sp. nov., *P. maxima* Green, *P. psidii* Mask, *Saissetia nigra* (Nientn.), *S. oleae* (Bern.) and *Vinsonia stellifera* (Westw) etc. (FLANDERS, 1942, 1959; SNOWBALL, 1970; GHANI & MUZAFFAR, 1974; CHUA, 1978). Hence, a comparative study of the population trend of healthy, dead (due to adverse climatic conditions) and parasitized individuals of *Pulvinaria* sp. was conducted for about one year covering seven consecutive generations, and the effectiveness of the parasite *A. ceroplastae* in controlling the population of this pest under field conditions was assessed.

MATERIALS AND METHODS

From 26th December 1982 onwards, the number of healthy, dead and parasitized coccids were counted instar-wise on twenty infested leaves at random once a week. The healthy instars were shining and straw-coloured, the dead coccids were dry and brown coloured whereas parasitized coccids were black or dark ash in colour. Ash coloured coccid had a minute emergence hole, through which the adult parasite had emerged out, and so these were also counted alongwith the black coccids for total number of parasitized coccids. The data were collected for about seven consecutive generations from the field, and the total

numbers and percentages were determined and recorded.

RESULTS AND DISCUSSION

Fig. 1 shows that from 26th Dec. 1982 to 25th Dec. 1983, seven generations of *Pulvinaria* sp. were passed one after another with slight overlappings between generations. In the third week of December 1982 new hatchings were observed from a few egg sacs present on the plants and thereafter the crawler population showed an upward trend. But from the first week of January 1983 the population showed downward trend due to the cold wave sweeping through this part of the country. Consequently, the number of dead coccids increased, hence mortality rate showed an upward trend. As the spring approached, the healthy coccid population showed a steep upward trend reaching the peak by 6th Feb. and, at the same time, the mortality curve showed a downward trend. However, on 30th January, a week before this coccid population peak appeared, the first symptom of parasitization (blackening of coccid's body) had been observed, which thereafter showed an upward trend. Due to this increasing number of parasitization the healthy coccid population showed a steep downward curve after 6th Feb., reaching near basal level in about three weeks. The parasite, *A. ceroplastae* was able to eliminate about 95% of coccid population from the field. However, reduction of the host population brought down the parasite population also in its consequence, which reached very low level by late March.

The second generation of coccid population started from 13th March when new hatchings were observed. It again showed an upward trend reaching the peak by 7th April. The parasitization which had been lying at a low level showed again an upward trend after 3rd April, when it was able to bring down sharply the healthy coccid population to near basal level, by 27th April. In other words, in about three weeks, about 95% of the coccid population was eliminated. On 3rd April, again dry, brown-coloured dead coccids were observed on the leaves

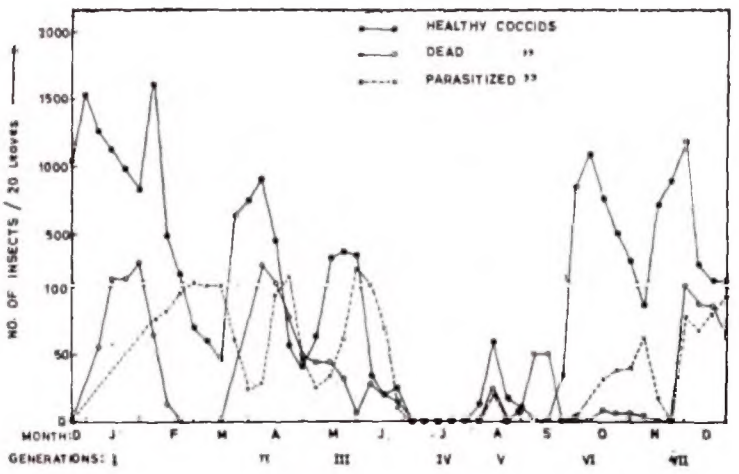

Fig. 1. Graph showing effect of parasitism by *Aneristus ceroplastae* on the population of *Pulvinaria* sp. during seven consecutive generations.

most probably due to the arrival of summer.

The third generation of coccids started from 30th April, when new hatchings were again observed on the leaves. The population again showed an upward trend, reaching the peak by 21st May, when close behind parasitization level also followed an upward trend. Within the next two to three weeks. i. e., by 15th June the coccid population was brought down to near basal level and by 30th June there was almost complete elimination of the host and parasite from the plant. In July, not a single coccid or its parasite was noticed on the plant but in the first week of August a few adult coccids were again seen laying eggs on the leaves. It was observed that some of the coccids had moved down below the soil level close to the root to protect themselves from the intense heat and the parasites in the month of June. Thus, a few of these survived coccids surfaced in early August. The fifth generation of coccids lasted from 1st August to 24th September, but again parasitization followed which brought down the population of the coccids to near basal level. The sixth generation of the coccid lasted from 15th Sept. to 15th Nov., in which the population again reached its peak by 7th October. The first symptom of parasitism was seen on 1st October which reached its peak on 7th November, bringing down the coccid population again. The seventh (last) generation started from 5th November and continued till middle of February, 1984. In this generation, first symptom of parasitism was noticed on 1st December, which showed a gradual upward trend, following closely the healthy coccid population. Thus the findings of the study of seven generations showed that (1) whenever coccid population rose, it was closely followed by a rise in parasitism level also, and in about two to three weeks

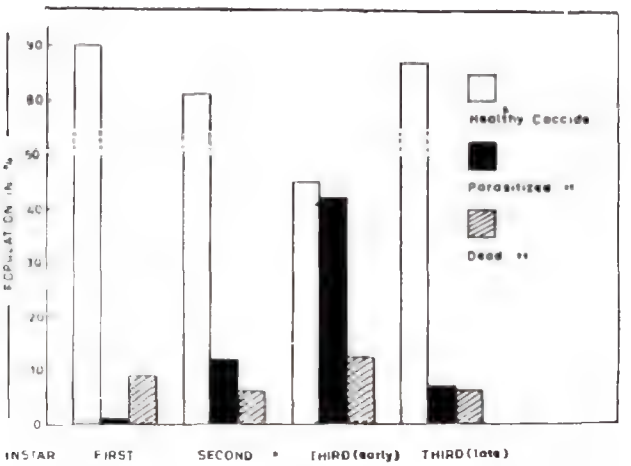

Fig. 2. Histogram showing percentage (total of seven generations) of healthy, parasitized and dead (due to climatic factors) coccids, in the first, second, third (early) and third (late) instars of *Pulvinaria* sp.

time, pest population was brought down and (2) in the month of late June and July the pest deserted the upper exposed part of the host plant and moved downwards below the soil level to escape the intense heat. The parasites were not found during this period, and it is presumed that they might have moved to new localities in search of suitable alternative host.

Figure 2 shows that the per cent of parasitism was lowest (0.8%) in first instar, higher (12.0%) in second instar, highest (42.0%) in the early third instar and again low (7.0%) in late third instar (adult female). Males were absent in *Pulvinaria* sp. The figure also shows that the parasitism not only killed the coccids but also prevented large number of bugs from reaching the oviposition stage, thus drastically bringing down the population in the next generation.

The adult of *A. ceroplastae*, an internal parasite of *Pulvinaria* sp., is a minute black hymenopterous insect which walks swiftly, visiting the coccids and oviposits within seconds by pushing its ovipositor into the body of the selected nymphs. CHUA (1978) reported that *A. ceroplastae* parasitized usually second instar *Saissetia nigra* (Nietner) scales in Malayasia, but late first and early third instar scales were also occasionally parasitized. He further reported that oviposition was quicker, took only 6–15 seconds and the female laid one egg per host. The parasite attacked 6–10 scales successively before it stopped. Our findings have also tallied with his observations. He concluded that *A. ceroplastae* was the most effective parasite as it parasitized the second instar, thus stopped the scale reaching the reproductive stage. But, surprisingly enough, in California several attempts to introduce *A. ceroplastae* to control *Saissetia* sp. in citrus orchards failed (FLANDERS, 1942, 1959). SNOWBALL (1970) reported that *A. ceroplastae* was the principal natural enemy of *Ceroplastes sinensis* on citrus in Australia. The parasite had also been recorded from *Coccus hesperidum* L., *C. pseudomagnoliarum* (Kuwana), *C. viridis* (Green), *C. longulus* (Douglas), *Ceroplastes euphorbiae* Cockerell, *C. actiniformes* Green, *Saissetia oleae* (Barnard), *S. coffee* (Walker) and *S. nigra* (Nietuer) (SNOWBALL, 1970).

As *A. ceroplastae* is able to parasitize several species of coccids belonging to different genera, it looks probable that it may prove an important biological control agent for the so called different species of *Pulvinaria* reported in this country. Our findings agree with the statement of GHANI & MUZAFFAR (1974) who stated that *A. ceroplastae* was the most important parasite of *Pulvinaria* sp. nov. Considering the toxic effect of insecticides on natural enemies of coccids (PHILLIPS *et al.*, 1962 & MCCLANAHAN, 1970), use of insecticides should be avoided as for as possible if activity of *A. ceroplastae* is observed, as from our study *A. ceroplastae* was able to bring down the population of *Pulvinaria* sp. in about 2–3 weeks time.

Acknowledgement. The authors are grateful to Professor J. S. DATTA MUNSHI, Head of the Post-Graduate Department of Zooloy, Bhagalpur University, for providing the necessary facilities for this work and to Dr. D. J. WILLIAMS and Dr. B. R. SUBBA RAO of the Commonwealth Institute of Entomology, London for identifying the coccid and its parasite. We also thank the University Grants Commission, New Delhi for financing this work, which forms a part of the UGC Research project granted to the first author (P K S).

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AGE STRUCTURE, NATALITY AND MORTALITY IN THE TROPICAL SPIDER *CYRTOPHORA CICATROSA* (ARANEIDAE, ARANEAE)

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(Received 19 October 1984)

Field studies on age structure, sex ratio, natality and mortality were carried out on the population of *Cyrtophora cicatrosa* inhabiting on the fence in Palani region of S. India. Of the total individuals collected during 1978-1979, second instar *C. cicatrosa* represented 35%. Sex ratio has been shifted in favour of females and is due to the fact that males get killed and eaten by females after copulation. Natality of *C. cicatrosa* affected by egg sac parasites, represented 55%. The spider encountered heavy mortality at different life stages of life cycle and it exhibited 'A' type of survivorship curve in which 70 to 90 % of mortality occurred before mid nymphal stage.

(*Key words: Cyrtophora cicatrosa*, age structure, mortality, natality, sex ratio)

INTRODUCTION

Spiders are important members of terrestrial invertebrate fauna. Consequently they have been the subject of a number of ecological investigations. Althouh ecological research on temperate spiders has made notable advances in the last three decades, studies on tropical spiders are meagre (ROBINSON & ROBINSON, 1973; HAMPREYS, 1976; VALERIO, 1977; PRAKASH, 1979) and yet to gain momentum. The present investigation, the part of four year programme on ecological investigation reports with the age structure, sex ratio, natality and mortality in the tropical spider *Cyrtophora cicatrosa* Stoliczka.

MATERIAL AND METHODS

Cyrtophora cicatrosa is an orb weaving spider which lives on fences of *Euphorbia antiquorum in* Palani region (10° 23'N and 77°C 31'E) of S. India, known for its extreme sexual dimoprhism. The young one becomes adult in about 75 days. In a span of 150 days of adulthood, many pear-shaped egg (max. 20) are oviposited like a beaded chain.

Field studies were carried out on the fence (L336 × H1 75 × B1.5m) adjacent to college campus. The fence borders dry land which is cultivated once in a year during monsoon season (October to Jan.). Fortnightly census of spider populations were made during the period from December 1978 to November 1979. Considering the number of individuals (No/m³) belonging to different life stages at successive fortnightly observations, mortality of spiderlings were calculated in terms of percentage. Between successive observations, new webs have been found in the study area; establishment of new webs is effected by II instar spiderlings, which are easily dispersed by ballooning (see VALERIO, 1977); hence calculation of mortality for the II instar was not possible Relating the number of individuals surviving at each stage to that in the previous life stage, survivorship was calculated.

In *C. cicatrosa* male or female passed through 6 or 9 instars before becoming adult. In the field, different life stages were

identified on the basis of weight. Sex was identified only in the adult stage in male and female can be distinguished in VII instar onwards. The ratio was calculated for adults during successive fortnightly periods. In the present investigation, natality has been taken to mean the number of spiderling emerging from the egg sac (cf. SOUTHWOOD, 1966; see also EDGAR, 1971a).

RESULTS AND DISCUSSION

Age structure

Fig. 1 shows the fortnightly changes in the frequency of different life stages of *C. cicatrosa* during 1978 and 1979. The part of histogram representing second instar was taller than that of other stages indicating a rapid growth during that stage. In this species, second instar individuals contribute a major proportion to the number. But, adult females contributed sizeably to the biomass. Of the total number of individuals collected during the year, second instar *C. cicatrosa* represented 35%. EDGAR (1971 a) observed that the age distribution of small instars changes relatively little from early March to May; but changes quickly between June and August in the temperate wolf spider *Pardosa lugubris* in Soctland.

Identifying an instar by weight is justified by (1) weight of a female corresponded more or less to the respective one reared in the laboratory, suggesting that the laboralory reared and field individuals passed through the same number of instars (2) the weight of an individual fluctuates during intermoult periods; overlapping of VII instar female and adult male makes the distinction of sex based body weight difficult. However, freshly moulted can be distinguished by the presence copulatory organs - a pair of modified pedipalps and (3) such procedure has been followed by previous authors (EDGAR, 1971a; PRAKASH, 1979).

Sex ratio

Literature on sex ratio and its changes in a spider population are scarce. HUMPREYS (1976) observed that the ratio was 1:1 in the burrow dwelling spider *Geolycosa godeffroyi*; JACSON & JOSEPH (1973) recorded that the ratio shifted in favour of female in *Stegodyphus sarasinorum*. MCQUEEN (1978) also found such a shift in *Geolycosa domifex*. PRAKASH (1979) has made continuous observation on the pattern of sex ratio in adult, *Pardosa leucopalpis* and *P. birmanica*. Table 1 shows that the ratio has been shifted much in favour of females and on application X^2 test (see HUMPHREYS, 1976), it became quite evident. Therefore, it may be concluded that such female biased sex ratio in the adult is due to the fact that males get killed and eaten by females after copulation (BLANKE, 1974); therefore, at the time of maturity the sex ratio is likely to have been 1:1 and subsequent to copulation it tends to be female biased. There is no supporting evidence for the female biased sex ratio at the time of hatching. The observation that males are eaten by famale after copulation is common among arachnids (e. g. HICKMAN, 1967). Such active elimination of males from the population may considerably help the mated females from hazards of the competition for prey (see RICKLEFS, 1973). The elimination of mated males and hence the avoidance of scope for genetically similar sperms being passed on to a number of females may have much implications from the point of genetics and evolution of spiders.

Natality

It is clearly known that a number of

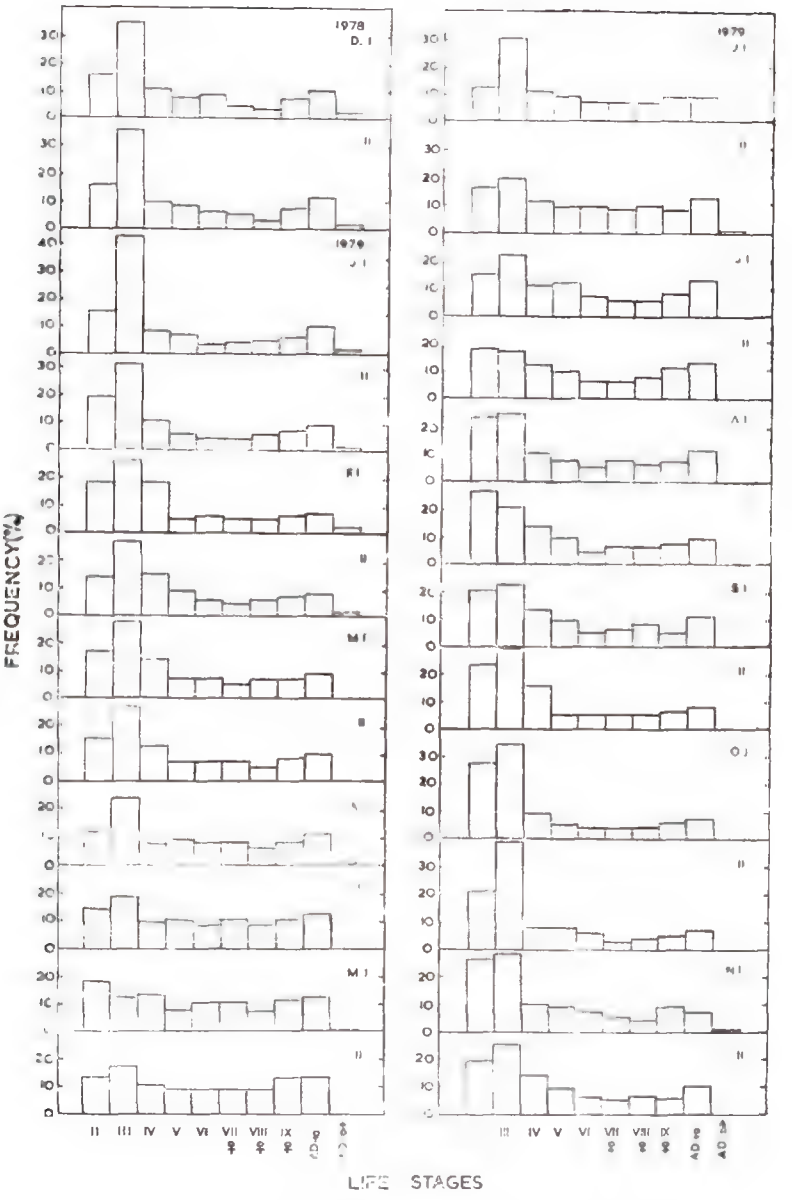

Fig. 1. Histogram representing fortnightly changes in the frequency distribution of different life stages of *C. cicatrosa* population during the period from (December 1978 to November 1979).

TABLE 1. Fortnightly population census of adult males and females of *C. cicatrosa* collected during one year period (X^2 tests were carried out to examine the departure from 1(1 sex ratio).

Period	female	male	X^2	P
December 1978	21	2	15.7	<.01
,,	26	1	23.1	<.01
January 1979	18	2	12.8	<.01
,,	22	2	16.7	<.01
February	9	1	6.4	<.02
,,	8	2	3.6	<. 1
March	5	1	2.7	<. 5
,,	4	0	4.0	<.05
April	4	1	1 8	<. 5
,,	5	0	5 0	<.05
May	6	1	3 6	<. 1
,,	5	0	5.0	<.05
June	5	1	2.7	<. 5
,,	6	0	6.7	<.02
July	5	1	2.7	< 5
,,	5	0	5.0	<.05
August	9	1	6.4	< 02
,,	11	2	6.2	< 02
Septembr	10	2	5.3	<.05
,,	12	0	12.0	<.01
October	18	1	15.2	<.01
,,	19	2	13.8	<.01
November	25	3	17.3	<.01
,,	24	3	16.3	<.01

parasites kill the spiderlings before emerging from the sacs; for instance, egg sac parasite *Sarcophaga banksi* has been reported to kill 88% of eggs of the spider *Argiope pulchella* (PRAKASH&PANDIAN, 1978). Despite the protection offered to the egg sacs by the female lycosids by arraying them attached to spinnerets, reports on parasitisation of sacs among the lycosids are not uncommon. Hence, EDGAR (1971b) regarded that provided the egg sacs are not parasitized, the number of eggs in a sac can be considered as the reasonable estimate of natality in lycosids. Despite the protection offered to the egg sacs by the female *C. cicatrosa*, egg sacs are parasitized by *Desantisca palanichami** (Hymenoptera : Eurytomidae). There is 44% mortality of *C. cicatrosa* eggs through parasitisation by *Desantisca palanichamyi*. Such egg sac parasitization is common among spiders (e. g. EDGER, 1971a; KESSLER & FOKKINGA, 1973).

Preliminary studies revealed that the removal of egg sacs to measure the weight of the sac did not result in rejection of egg sacs by the female. Since the removal of egg from the sac was found to affect incubation, direct counting of eggs was avoided in the estimation of natality (PALANICHAMY & PANDIAN, 1983).

Indirect method adopted in the present study to estimate the number of eggs present in the field involved estimation of number of eggs calculated from weight of egg sac subtracting the weight of silk. Fortnightly changes in the number of eggs produced by a female ranged between 13 and 50 (Table 2); besides, 50% of the values were between 13 and 24. The peak in egg production (No./m^3) observed coincided with maximum density of egg laying females.

During the period of 12 months (December 1978 to November 1979), 105 egg sacs *C. cicatrosa* were carefully analysed for the incidence of parasites. Out of 3207 eggs produced, 1409 were parasitised and killed; the remaining 1798 eggs were taken to represent natality (Table 3).

* Indentified by Dr. Narendran, Calicut Univerversity, India (Entomon 9: 1—10; 1984)

TABLE 2 Fortnightly changes in number of eggs laid by an average female *C. cicatrosa* during 1978—1979.

period			number of eggs $\bar{x}$	SD
December	1978	I	50	8.4
		II	42	6.5
January	1979	I	41	7.5
		II	41	2.9
February		I	36	3.1
		II	32	2.8
March		I	28	4.8
		II	28	2.8
April		I	20	1.8
		II	18	1.8
May		I	16	2.0
		II	14	1.8
June		I	19	2.2
		II	21	2.0
Jaly		I	19	2.6
		II	17	1.5
August		I	13	1.8
		II	19	1.6
September		I	24	2.1
		II	21	2.4
October		I	29	2.2
		II	33	2.6
November		I	41	5.1
		II	46	9.2

TABLE 3. Fortnightly changes in the number of egg/m3 laid by females *C. cicatrosa* and natality of spiderlings emerged on the fence in the vicinity of Palani.

Period		total number of eggs	natality
December	1978	326±48	183
,,		332±96	186
January	1979	282±70	158
,,		265±56	148
February		220±44	123
,,		194±36	110
March		126±28	71
,,		137±31	77
April		97±21	54
,,		46±12	26
May		21± 7	12
,,		24± 6	13
June		22± 5	12
,,		19± 4	11
July		26± 5	15
,,		32± 7	18
August		49± 9	27
,,		74±12	40
September		126±14	71
,,		166±14	93
October		141±13	79
,,		137±16	77
November		144±15	81
,,		201±27	113
Total		3207	1798

Barring the publication by SCHAFFER (1978) which reports data on egg density and biomass for web building spider population, no work is available. He reported a maximum of 142 eggs/m² and minimum of 98/m² for sheet web spider *Floronia bucculenta* during September 1976 in Kiel, West Germany and found that suitable web sites for the construction of web seemed to be the ultimate factor limiting the population size. WINGERDEN (1978) also presented some data on egg density of *Erigone arctica* (range 38 to 507 eggs/ generation, for different generations from 1971—1975) and suggested that the density of *Hypogastrura viatica* (main prey) is important factor with respect to the fluctuation in spider density. Comparison of the units adapted by the above authors poses problem; however, in contrast to these values, density obtained for *C. cicatrosa* averaged to 134 eggs/m³ for whole (Table 3); the range from 19 to

332 eggs/m³ observed may reflect the density of adult females. In units of an individual, a female *F. bucculenta* produced 75 eggs during month of September 1976. In comparison to the above, egg laying capacity of *C. cicatrosa* is higher at 27°C, a female fed *ad libitum* produced 462 eggs; egg production was 524, 809 or 500 eggs/female during monsoon seasons of 1976, 1977 and 1978; they were also able to maintain high density in the field (3 8/m³) (also increasing the frequency of oviposition more than 3 times) as there were many egg laying females per unit space at any time of observation. From this analysis, it is suggested that the natality of spider must be considered both in terms of fecundity of an individual spider and the density of egg producing females in a population.

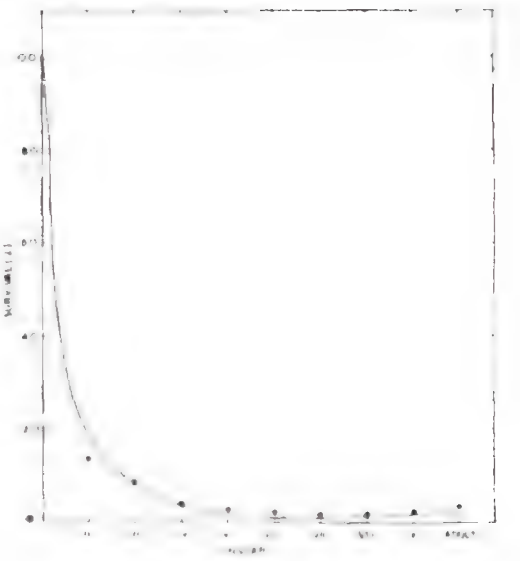

Fig. 2. Survivorsip curve of *C. cicatrosa* II instar spiderlings are met with heavy mortality during dispersal stage.

Mortality

CLARK *et al* (1972) describe mortality in a population to one or more of the following causes: 1. aging, 2. predation including parasitization and cannibalism and 3. extreme climatic factors. Death due to improper moulting process is also common among spider (TURNBULL, 1973). A sizable proportion of spider is reduced by insect parasites (eg. KASTON, 1948; EDGAR, 1971a; KESSLER & FOKKINGA, 1973) and predatoty arthropods (BRISTOWE, 1928; DORRIS, 1969; 1970; KASTON, 1959; MUMA & JEFFERS, 1945). Among spiders, a female is known to eat the male after copulation (EDGAR, 9971b; BLANKE. 1974). Web building spiders catch the prey by chance encounter and hence are known to show considerable ability to withstand starvation. In spite of its ability to tolerate starvation, the orb web spiders like *C.cicatrosa* encounter heavy mortality (especially during second instar) at different stages of life cycle (Fig. 2).

Mortality of *C. cicatrosa* population during summer season was higher (98.9%) than that of monsoon population (84.7%) and it averaged to 88.5% for the year (Table 4). Failure to establish web and procure prey in time appears to be the main cause for the juvenile mortality in web building spiders. Beside insects and spiders like *Marpissa calcutaensis*, predators such as *Calotes versicolor*, *Mabuya* sp. and *Geckos* sp. were observed to feed on *C. cicatorsa*; thus the mortality also increased by these predotors. As mentioned earlier, 44% mortality by a hymenopteran parasite was recorded. Such high percentage of mortality indicates the possibility of 'A' type survivorship curve (Fig. 2). VALERIO (1975; 1977) has shown that 99% of an emerging population of web building spider *Achaeranea tepidariorum* is in dispersal stage; this dispersing population is characterised by the highest mortality rate

TABLE 4. Percentage mortality of different life stage of *C. cicatrosa* population during December 78 to November 1979. Each value represents the mean of several observation of respective stages.

Life stage		Summer	Monsoon	Mean
Egg	♀♂	56.6	44.4	50.5
II	♀♂	87.0	76.2	81.6
III	♀♂	96.2	82.4	89.3
IV	♀♂	97.3	87.4	92.4
V	♀♂	92.6	90.6	91.6
VI	♀♂	97.8	91.2	94.5
VII	♀	98.9	92.4	97.7
VIII	♀	92.4	90.6	91.5
IX	♀	98.9	90.6	94.8
Adult	♀	95.4	92.4	93.5
..	♂	98.8	93.4	96.1
	Average	92.3	84.7	88.5

(98%) presumably due to starvation. He has also demonstrated this dispersal stage has a very low survival rate (i.e. less than 2%). Therefore, web building spiders like *C. cicatrosa* exhibit 'A' type (see PRICE, 1975) survivorship curve. Mortality of *C. cicatrosa* was generally low during later nymphal and adult stages.

C. cicatrosa suffered heavy initial mortality, until it got dispersed and established on strategic location and become self sufficient. Subsequently, the scope for mortality is less. In hunting spiders like *Pardosa* sp. the question of selecting a strategic location and establishing a web does not arise. Hence they incur no heavy initial mortality, but suffer continuous predation. Hence, they exhibit a straight line survivorship curve (see PRAKASH, 1979). A similar survivorship curve has been reported for *Geolycosa godeffrogi* (HUMPREYS, 1976). Hence, it appears that during the course of evolution of web building spiders, not only predatory strategy has been altered but also the pattern of survivorship curve.

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STUDIES ON THE SEASONAL PREVALENCE OF CERTAIN HEMIPTERA OCCURRING ON SORGHUM

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The seasonal prevalence studies at Hyderabad of *Rhopalosiphum maidis, Perigrinus maidis* (Ashmead), *Nezara viridula* Linn., *Dolycoris indicus* Stal., *Lygaeus pandurus* (Scop) and *Calocoris angustatus* Leth, revealed that the populations were found to be highly correlated to average minimum temperature except with regard to *D. indicus.* Significant correlation was observed between the pepulations of *R. maidis* and *C. angustatus* and the average relative humidity. The correlation coefficients between the populations of the different species and the average maximum temperature were not significant.

(Key words: sorghum, *Calocoris angustatus, Dolycoris indicus, Lygaeus pandurus, Nezara viridula, Rhopalosiphum maidis, Perigrinus maidis,* weather factors)

INTRODUCTION

Sorghum, the second major staple food crop of India is attacked by about 100 insects and among them about 25 species belong to the order Hemiptera. REDDY & DAVIES (1977) listed about 25 species. These bugs suck the vital plant juices resulting in the loss of vigour of the plant, reduction in tiller production and filled grains. Many of them act as vectors of virus diseases of plants. In the pest management programmes the basic need is the information on the seasonal prevalence of the pests. As the information in this regard on the Hemipterous insects on sorghum is scanty an attempt has been made to study the prevalence of the important Hemipterous species in relation to the age of sorghum crop and the weather factors like temperature and relative humidity.

AYYAR (1963) reported that sorghum crop escapes the damage of earhead bug *Calocoris angustatus* Leth. when the crop is sown before March 15th at Coimbatore. He also reported green coloured aphid *Rhopalosiphum maidis* (Fitch) infesting sorghum in the month of November and their population reaching the maximum during the months of January and February. MONGOLI (1968) reported *C. angustatus* occurring on sorghum in the month of January. The seasonal incidence studies of HIRAMATH & THONTADARYA (1984) on the sorghum earhead bug in Karnataka state revealed that the population was higher during January which coincided with the blooming and milky stages of the grain. CHELLAIAH & BASHEER (1965) reported the occurrence of *Perigrinus maidis* (Ashmeed) abundantly on sorghum during September to January at Coimbatore. The populations got reduced from February onwards and became extremely scarce during the period from March to June.

* Part of the M Sc. (Agric.) thesis submitted by the first author to the Andhra Pradesh Agricultural University, Hyderabad in 1979.

MATERIALS AND METHODS

A sorghum plot of 36 m² with '*CSV 4*' variety was raised at the Agricultural College, Rajendernager, Hyderabad during 1976. The crop was sown on 15-10-1976 with a spacing of 45×16 cm. Population counts were taken from the age of ten days of the crop and continued regularly till 110 days age of the crop. Five per cent of the plants were selected at random and population counts of *Rhopalosiphum maidis*, *Perigrinus maidis*, *Nezara viridula*, *Dolycoris angustatus*, *Lygaeus pandurus* and *Calocoris angustatus* were recorded. The aphid populations were counted on three leaves, taken at random from each plant. Popualtions of shoot bugs were recorded from leaf whorls and leaf sheaths. For recording the earhead bugs the panicles were shaken against an oil paper and their populations were counted. For the population counts of other plant bugs their number on each plant was recorded. The weather data, obtained from the Meteorological station, Rejendernagar has been furnished in Table 1.

The linear correlation coefficients and the regression coefficients between the populations of the Hemipterous species and climatic factors have been worked out and the data presented in Table 2. The insects were sent to Zoological Survey of India, Calcutta for identification.

RESULTS AND DISCUSSION

The population of *R. maidis* increased even from ten days age of the crop during the last week of October. The peak population (450) was reached during last week of November at 40 days age of the crop from its initial population of 120 at ten days age of the crop. With the maturity of the crop, the population of the species dwindled down and became nil at 90 days age of the crop.

The population of *P. maidis* increased from ten days age of the crop and the peak populatlon (678) was observed at 70 days age of the crop during the last week of December. Among the pentatomids, *N. viridula* showed a peak population of 85 at 80 days age of the crop during the first fortnight of January and it was present throughout the crop period. *D. indicus* was found throughout the crop growth in small numbers (4 to 47). Maximum population (47) was observed during the last week of December at 70 days age of the crop. *L. pandurus* was found to be dominant next to *N. viridula*. The peak population (49) of *L. pandurus* was observed at 70 days age of the crop. From this it can be inferred that the pentatomid population was maximum from the last week of December to the first fortnight of January (70 to 80 days age of the crop). Afterwards their population decreased gradually.

The mirid *C. angustatus* was found to occur during the month of December at the earhead formation stage. Their population increased gradually along with the crop attaining the milch stage in grain. The earhead bug reached its peak population (380) during the third week of January (90 days age of the crop) and showed a steep fall in its population synchronising with maturity of the earheads, thus confirming the trends given by CHELLIAH & BASHEER (1965), MANGOLI (1968) and HIRAMATH & THONTADARYA (1984).

The linear and regression correlation coeffcients indicated that the populations of all the species were found to be highly correlated with the minimum temperature except with regard to *D. indicus*. No significant correlation existed between the populations and the average maximum temperature. Significant correlation between population and average relative humidity was observed among *R. maidis* and *C. angustatus*. It was found that there was a significant positive correlation at five per cent level between the population of *R. maidis* and average minimum

TABLE 1. Population data of hemipterous species associated with rabi jowar crop at Hyderabad in relation to certain climatic factors during 1976—1977.

Date	Age of the crop (days)	*R. maidis*	*P. maidis*	*N. viridula*	*D. indicus*	*L. pandurus*	*C angustatus*	Average Maxi. temp. (°C)	Min. temp. (°C)	RH (%)	Rain fall (mm)
30-10-1976	10	120	80	6	4	—	—	32.50	18.54	53.1	—
9-11-1976	20	356	240	12	8	4	—	29.51	18.67	68.5	3.60
19-11-1976	30	420	320	14	12	8	—	29.22	19.20	75.2	1.54
29-11-1976	40	450	485	26	14	12	—	27.12	19.90	71.65	7.10
9-12-1976	50	380	500	44	18	35	15	29.54	15.49	69 25	—
19-12-1976	60	200	650	48	24	46	175	27.63	13.07	66.95	—
29-12-1976	70	120	678	52	47	49	188	29.00	11.49	58.15	—
9- 1-1977	80	80	236	85	21	32	245	28.84	10.39	56.95	—
18- 1-1977	90	—	128	75	18	24	380	29.94	12.00	55.10	—
28- 1-1977	100	—	110	60	9	12	250	28.94	13.94	58.35	—
7- 2-1977	110	—	28	32	4	6	200	29.61	13.70	61.70	—
Total		2126	3455	454	179	228	1453				

TABLE 2. Linear correlation coefficient and regression coefficient between the population of certain hemipterous species and climatic factors.

Sl. No	Particulars	correlation coefficient (r)	regression coefficient (b)	Constant (a)
1	Population of *R. maidis* and average maximum temperature	−0.3216NS	41.2928	1401.6150
2	Population of *R. maidis* and average minimum temperature	0.7228*	37.1557	−369.7723
3	Population of *R. maidis* and average maximum temperature	0.9135**	23.5219	−1303.3649
4	Population of *P. maidis* and average maximum temperature	−0.5885NS	−97.9363	3180.8833
5	Population of *P. maidis* and average minimum temperature	−0.7392*	−4.9697	390.1736
6	Population of *P. maidis* and average relative humidity	0.3955NS	13.1996	−524.858
7	Population of *N. viridula* and average maximum temperature	−0.2983NS	−5.6059	205.3188
8	Population of *N. viridula* and average minimum temperature	−0.8812**	−6.6897	142.4649
9	Population of *N. viridula* and average relative humidity	−0.5974NS	−2.2514	184.526
10	Population of *D. indicus* and average maximum temperature	−0.3583NS	−3.1553	108.6069
11	Population of *D. indicus* and average minimum temperature	−0.5489NS	−1.9526	45.8091
12	Population of *D. indicus* and average relative humidity	−0.1879NS	−3.3184	37.3870
13	Population *L. pandurus* and average maximum temperature	−0.4267NS	−5.3701	177.8732
14	Population of *L. pandurus* and average minimum temperature	−0.6824*	−3.4700	73.2165
16	Population of *L. pandurus* and average relative humidity	−0.1701NS	−4.2940	48.0537
16	Population of *C. angustatus* and average maximum temperature	−0.10135NS	−9.8797	421.1986
17	Population of *C angustatus* and average minimum temperature	−0.8623**	−34.0018	646.2916
18	Population of *C. angustatus* and average relative humidity	−0.7493**	−14.6485	1064.1381

NS—Not significant *—Significant at 5% level **—Significant at 1% level

temperature and also positive correlation at one per cent level between the population and average relative humidity. The correlation coefficient between the population of *P. maidis* and average minimum temperature was negatively significant at five per cent level. The correlation coefficient between the population of *N. viridula* and average minimum temperature at one per cent level was negative. No significant correlation existed between the population of *D. indicus* and climatic factors. Significant negative correlation was observed at five per cent level betweeen the population of *L. pandurus* and average minimum temperature. However, the population of *C. angustatus* showed significant negative correlation at one per cent level with the average minimum temperature and relative humidity.

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FORAGING PATHS OF THE ANT, *CAMPONOTUS SERICEUS* FABRICIUS

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From each nest of the ant *Camponotus sericeus*, as many as sixteen foraging paths were observed radiated in all directions. Total distance of the foraging paths from nest to food source ranged from 1 to 78 45 metres. Distance from the food source to the nest ranged from 1 to 74.15 metres. Time taken to cover the distance from the nest to the food source and back was 4 to 112 min and 1 to 78 min respectively. More time taken by the foragers to cover the distance from the nest to the food source was due to spending time in search of food source. Longest paths were observed in summer months (February to May) and the shortest during rainy months (June to September). The length of the foraging paths were directly proportional to the availablity of food nearby the nest area.

(*Key words:* foraging path, ant, *Camponotus sericeus*)

INTRODUCTION

It is evident from the available literature that the foraging paths in ants are species specific. PICKLES (1947) has desscribed the use of permanent track way by the ant *Messor barbarus barbarus*. HARKNESS (1980) has clearly demonstrated the presence of two distinct foraging pathways such as, 'search paths' and 'shade or lick paths' in *Cataglyphis bicolor*. Since no information is available in the ant *Camponotus sericeus*, in the present investigation, the authors have made some observations to find out the length and direction of the foraging paths and to reveal the relation between types of foraging paths and the availability of food in different seasons of the years 1979 and 1980.

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MATERIALS AND METHODS

Ten nests and their inhabitants of the ant *Camponotus sericeus* around Karnatak University Campus, Dharwad comprised the materials for the present study. About 100 individual foragers going out of each nest to the food source and back to the nest were followed and the length, direction and types(s) of foraging paths and the time taken to cover the distance recorded. (Table 1). The above observations of all the types of foraging paths are diagrammatically shown in Figs. 1—16.

OBSERVATIONS

During rainy season the foraging area was found covered with green grass, bushes, shrubs and other plants, which attracted phytophagous insects and their larvae. In summer months (February to May) the foraging area was covered with only dry vegetation and availability of food was less. From each nest, in every season, as many as 16 foraging paths radiating in all directions of the

TABLE 1. Duration and length of foraging paths of the ant, *Camponotus sericeus*.

Types of foraging paths	distance of foraging paths from nest to food source m	time taken cover the distance from nest to food source min	distance of foraging path from food source to nest m	time taken to cover the distance from food source to nest min	total distance of foraging paths from nest to food source and back m	time taken to cover the distance from nest to food soure and back min
Paths leading to bushes, shrubs and other places	1.00—18.10 (8.4 ± 2.4)*	5.00—112.0 (31.5 ±18)	1.00—15.00 (6.17± 1.15)	1.00—78.00 (17±10)	2.00—28.50 (14.8 ±5)	9.00— 90.0 (48.5 ± 28)
Paths leading to the covered runways of termites	2.5 — 5.02 (3.4 ± 0.3)	4.00— 17.00 (10.0 ± 2)	1.13— 3.37 (2.2 ± 0.2)	2.00—14.00 (3.3 ± 0.8)	3.36— 8.37 (5. 6± 5)	6.00— 27.00 (13.0 ± 2)
Paths leading to trees	16.00—78.45 (48.0 ±22)	20.00—67.0 (59.6 ± 2.6)	2.80—74.15 (30.5 ±21)	35.00—46.00 (41.0 ± 0.4)	30.35—152.60 (78.5 ± 43)	92.00—108.0 (100.6 ± 3)

* values in parentheses are the mean ± SE of 100 observations in each nest.

nests were observed. The foraging paths during summer months measured from 2.00 to 152.60 m in length, but in rainy months (June to September) they measured between 2.00 and 28.50m.

To trace the generalised foraging paths, outgoing foragers from the nest were followed to food source and back to the nest in different seasons of the years 1979 and 1980. Five per cent of foragers found entering into the other nests of the same species. After 10 to 35 seconds such ants came out of the nest and moved towards their nests. In a few cases, the wrongly entered ants were actually driven out of the nests by the inmates by carrying them in their mandibles. Such ants were left at a distance of 8-12 cm away from their nests.

According to the avilability of food and food sources, the foraging paths are categorised as follows :

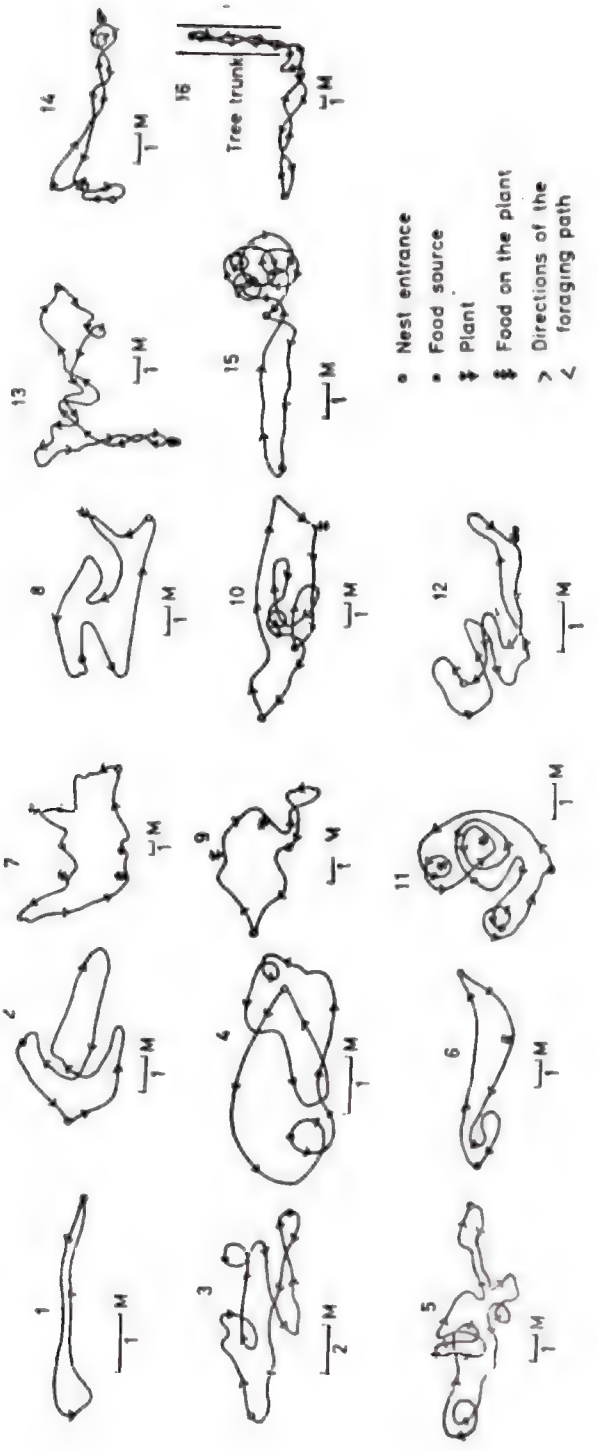
i. Foraging paths leading to bushes, shrubs and other places,
ii. Foraging paths leading to the covered runways of termites, and
iii. Foraging paths leading to trees.

i. Foraging paths leading to bushes, shurbs and other plants.

During rainy season the area around nest was covered with green vegetation and attracted several phytophagous insects and their larvae. During this period the foraging ants were invariably found feeding on these insects and their larvae. The foraging paths leading to bushes, shrubs and other places in these instances varied from 1.00 to 18.10 m in length, whereas, those paths leading to the nest varied from 1.00 to 15.00 m. The time taken to cover the distance in the above mentioned cases was 5 to 112 (31.5±18.0) min and 1 to 78 (17±10) min respectively. The spot-fed foragers and those carrying small preys were observed, took only 1.00 to 12.20 (4.0 ± 1.2) min to reach the nests from the food source. Foraging paths as shown in Fig. 6 to 14 were frequently observed from October to March. The foragers while climbing the plants were found examining the stems and leaves, several times, with their antennae. Later, they were found scraping the surface of the leaves and stems for sap. Some of the foragers devoted 10 to 45 (26±10) min especially at extrafloral nectaries and on aphids in order to collect the liquid food. At such places foragers spent more time in procuring the liquid food. Such foragers took less time (3.0 m/min) to reach their nest than to reach the food source (0.50 m/min). The gasters of the foragers fed with liquid food were found swollen and translucent. Some foragers even after procuring liquid food were noticed, going in search of food. Some of them were found engaged in collecting the termites and other dead/live insects of the body parts of insects (Figs. 6 to 11).

ii. Foraging paths leading to covered runways of termites (Figs. 1—5 & 15)

The foraging paths towards the covered runways of termites were observed throughout the year, but more frequently during the late winter and summer months (December–May) when there were many of the covered runways of termites over the dried grass, bushes and even the trunks of the trees situated near the nests. The distance of the foraging paths to such places varied from 3.36 to 3.37m. The outgoing foragers were found traversing 0.34 m/min from the nest to food source for procuring the termites as their food. The foraging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Tree trunk
1 M
2 M
• Nest entrance
• Food source
Plant
Food on the plant
> Directions of the
< foraging path

ants examined the runways of termites several times from 10 to 90 (50±17) seconds at different places and then they broke open the covered runways by the mandibles in order to have an access to the termites. These foragers took more time to reach the food source from the nest. After collecting the termites in their mandibles the foragers rushed back to the nests. Such foragers took 3.3±0.8 min to cover an average distance of 2.2±0.2m to reach the nest from food source. In a few cases, foragers returning with food took a few rounds nearby the nest and then found entrance into the nest. Such foragers took more time to reach the nest (11 to 23 min; Figs. 4 & 15).

iii. Foraging paths leading to trees (Fig. 16)

During winter and summer months (December to May) it was noticed in Dharwad that tree trunks were invariably covered by the runways of temites. During these months some of the trees were also found bearing the flowers. The frequency of foraging paths leading to the trees was found to be more during these months. Among all the foraging paths of the ant, *C. sericeus*, the above mentioned paths were longest ranging from 30.35 to 152.60 m (Table 1). The foragers were seen climbing the trees up to the average height of 5.1±2.0 m for collecting the nectar. Time taken to reach the food source on the trees varied from 35 to 46 min.

DISCUSSION

The available literature on the types of foraging paths and their number in the ant species has revealed that the length of the paths is directly proportional to the availability of the food source. In different species of ants, the foraging paths varied in their shape and length. PICKLES (1947) reported that the ant *Messor barbarus barbarus* followed permanent track ways to their food sources. Further, he noticed the presence of varied diversions. MARKIN *et al.*, (1975) showed subterranian foraging tunnels in the mound building ants of *Solenopsis invicta*. They also showed the varying number of foraging tunnels with the size of the mound. HARKNESS (1980) clearly described the presence of two distinct and generalised paths in the desert ant, *Cataglyphis bicolor* : (i) search paths, wherein, the ant goes rapidly in search of food without any hesitation, (ii) lick path or shade path, wherein, the ant always lick the surface while visiting the plant or occasionally other food sources. These paths are generally found in the shady places and hence are called as shade paths.

The present study revealed that the length of the foraging paths and the time taken to cover the distance were proportional to availability of the food. In winter and summer months the foraging paths were longer 30.35 to 152.60m (Fig. 16), whereas, they were shorter during rainy months. This is due to the fact that in summer, the area around nest was dry and the availability of insect food was least, whereas during rainy months there was much green vegetation around the nests and the food was in abundance. ROGER (1974) reported that foraging distance varied with conditions of the pasture. The maximum length of the foraging paths in the light and heavy meadow was 14.3m and 11.0m and the time taken was 65.0 and 67.0 min respectively. MARKIN *et al.* (1975) observed that the distance of foraging tunnels (1 to 2 m) was depending upon the food source. HARKNESS (1980) is also of the opinion that the length of

the foraging paths (5 to 46m) is directly proportional to the availability of food. The present investigation in the ant *C. sericeus* revealed 16 or more number of foraging paths. As described by HINGSTON (1929) and HOLLDOBLER *et al.* (1974) these ants in the present investigation used tandem running techniques in recruiting the foragers for searching/reaching the food sources and hence, as many as 16 or more number of foraging paths were observed for food gathering.

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HOST SPECIFICITY AND BIOLOGY OF PADDY GREEN LEAFHOPPER NEPHOTETTIX SPP.

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Fourteen host plants including rice were tested for green leafhopper development. *Nephotettix nigropictus* (Stal.) completed the life cycle on *Echinochloa colonum, Oryza spontenea* and rice. *N. virescens* (Distant) completed the life cycle on *Leersia hexandra* also in addition to the above. A number of food hosts for both green leafhopper species were identified. There is a significant variation in different insect biological events on the different reproductive hosts. Hosts other than rice and wild rice retarded the development.

(Key words: paddy green leafhoppers, host range)

INTRODUCTION

Insects are known to be adaptive in diversified environmental conditions, which influence the reproductive phenomenon and the life of the insects (EMMEL, 1975). Amongst the environmental conditions, food is a decisive factor (KENNEDY, 1965). The green leafhopper *(Nephotettix* spp. a major pest of rice, in all the rice growing tracts of world (NASU, 1964; GHAURI, 1971) including India (ANJANEYULU & CHAKRABARTI, 1977) is a polyphagous insect. A large number of plant species were reported as alternate hosts (NASU, 1964; RAO & ANJANEYULU, 1977; MISRA, 1980; ANJANEYULU *et al.*, 1981). The insects undergo their life cycle partially or completely on these hosts with variations in developmental rate and adult longevity (DHAWAN & SAJJAN, 1977). In Madhya Pradesh, rice is mainly grown in Kharif season and in the absence of rice for a fairly long period the role played by alternate host plant species existing in the environment in the maintenance of the insect population is not fully known. The present paper reports results of studies undertaken at M. P. Rice Research Institute, Raipur Madhya Pradesh.

MATERIAL AND METHODS

Cultures of *Nephotettix virescens* and *N. nigropictus* were maintained on the rice variety *T(N) 1*. Thirteen graminaceous plants commonly occurring in Madhya Pradesh (See Table 2) in addition to rice were grown in the laboratory. On each test plant one pair of freshly emerged adults of the the insect was released and based upon their activity the host plants were classified as reproductive hosts (the plants on which complete development of the insect took place) and food hosts (on which complete development of the insect was not possible) for both *N. virescens* and *N. nigropictus*. Biology of the insects was studied on the reproductive hosts. The data obtained were subjected to statistical analysis following the method advocated by PANSE & SUKHATME (1957). In case of food hosts the longevity of udult insects was ascertained.

[1] Central Rice Research Institute, Cuttack (Orissa) 753 006 Part of Ph.D. thesis submitted by thefirst author to Ravishankar University, Raipur (M. P.).

TABLE 1. Duration of different biological events of *N. virescens* and *N. nigropictus* on different hosts (in days).

Host	Oviposition period	Incubation period	Nymphal period (instars)						Longevity	
			I	II	III	IV	V	Total	Female	Male
Wild rice										
Range	36—56	6—8	2—3	2—4	3—4	3—5	5—6	16—22	34—68	32—50
	(40—50)	(5—8)	(3—4)	(3—4)	(4—6)	(4—6)	(3—7)	(17—27)	(42—54)	(36—47)
Mean	47.0	6.3	2.6	2.9	3.6	4.4	5.4	18.9	51.1	42.6
	(44.5)	(6.4)	(3.4)	(3.4)	(4.3)	(5.0)	(4.8)	(20.9)	(48.5)	(41.1)
E. colonum										
Range	35—50	6—8	2—4	3—4	3—5	3—4	5—7	16—24	43—58	37—48
	(42—47)	(5—9)	(3—4)	(3—5)	(4—7)	(4—6)	(4—7)	(18—29)	(48—60)	(39—48)
Mean	44.6	6.8	3.2	3.6	4.0	3 4	5.8	20.0	52.1	42.8
	(44.1)	(7.1)	(3.5)	(3.8)	(3.8)	(5.2)	(6.7)	(23.0)	(54.9)	(43.5)
L. hexandra										
Range	38—51	5—7	2—4	2—5	4—5	3—4	5—7	16—25	48—60	37—53
Mean	44.9	5.8	2.7	3.6	4.2	3.6	5.9	20.0	54.2	42.2
Rice										
Range	34—55	5—8	2—3	2—4	3—4	3—4	4—6	14—21	52—68	43—57
	(36—60)	(4—6)	(2—4)	(3—4)	(3—5)	(3—5)	(3—5)	(14—23)	(52—70)	(48—68)
Mean	47.6	5.7	2.5	3.1	3.5	3.5	4.7	17.3	63.5	50.2
	(55.5)	(5.0)	(2.7)	(3.4)	(3.3)	(4.0)	(3.6)	(17.0)	(62.3)	(57.7)
C D 5%	0.83	1.85	1.30	0.79	1.76	2.94	2.18		2.47	1.83
	(2.92)	(4.16)	(1.84)	(1.23)	(1.26)	(2.02)	(4.23)		(3.89)	(5.50)

N. B. The figures in parantheses are for *N. nigropictus*.

RESULTS AND DISCUSSION

The studies indicated that *N. nigropictus* survived and completed their life cycle on the alternate hosts *Echinochola colonum*, and *Oryza spontanea*, and *N. virescens* on these and on *Leersia hexandra*. Significant variations in oviposition, incubation period, nymphal duration and adult longevity were noted in case of both species on the different host plants (Table 1). The trend of variation in the different insect events on the reproductive hosts was the same in both species. The incubation period was prolonged significantly when insects were reared on reproductive hosts other than rice while the oviposition duration was shortened. Although the number of nymphal instars were the same, its duration was significantly influenced by the host and marked variation was observed in case of 4th and 5th instars in case of both species.

The adult longevity of male and female was also affected by the hosts on which they fed. The life-span was significantly shortened on the alternate hosts as compared to rice, the females surviving for longer periods than the males.

Survival of adult hoppers on different alternate hosts varied from 3 to 53 days (Table 2). ANJANEYULU & CHAKRABARTI (1977) considered as potential food hosts those on which the insect survived for more than ten days considering the fact that the leafhopper survived even without food up to eight days. Based on the above criteria *E. indica*, *L. hexandra*, *P. distichum* and *C. dactylon* could be considered as potential food hosts for *N. nigropictus* and *S. officinarum*, *P. distichum*, *P. crus-galli*, *C. dactylon* and *E. indica* for *N. virescens* in addition to their reproductive host plants already mentioned above.

TABLE 2 Longevity of *Nephotettix* spp. on different alternate hosts.

Host plants	Adult longevity in days	
	N. nigropictus	*N. virescens*
Echinochloa colonum	25	23
Paspalum distichum	14	9
Cynodon dactylon	18	14
Eleusine indica	14	12
Leersia hexandra	9	21
Eragastris sp.	8	8
Panicum crus-galli	7	9
Cyperus rotundus	5	8
Triticum aestivum	6	7
Saccharum officinarum	8	11
Zea mays	7	6
Fimbristylis milliacea	4	4
Oryza spontanea	28	32
Rice-*T(N) 1*	46	53
None	3	4

* Average of 10 replications.

In the present studies *N. virescens* did not survive on *T. aestivum* which was reported as a reproductive host by NASU (1964). Similarly *E. indica* reported by MISRA (1980) as reproductive host was found to serve only as a food host for the leafhopper. Also *N. nigropictus* did not survive on *C. rotundus* and *Zea mays* in repeated tests though DHAWAN & SAJJAN (1977) RAO & ANJANEYULU (1977) and MISRA (1980) reported them as food hosts.

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EURYTOMA SP : A NEW PARASITE ON *ASPHONDYLIA* SP. INFESTING EGGPLANT

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(Received 14 November 1984)

Eurytoma sp. has been recorded for the first time as larval parasite of gallmidge, *Asphondylia* sp. infesting eggplant. The extent of paraitization ranged from 8 to 15 per cent

(Key words: Eurytoma sp., *Asphondylia* sp., larval parasite, eggplant).

HARRIS (1938) first listed gallmidge, *Asphondylia* sp. (Diptera : Cecidomyiidae) as one of the injurious pests of eggplant *(Solanum melongena* Linn.) in Tanganyika. MANI (1953) reported brinjal gallmidge for the first time in India and described it as *Asphondylia beguni* Mani. He further described the morphology of galls formed by the species on brinjal flowers MANI (1973). KRISHNAIAH *et al.* (1975) reported a gallmidge, *Asphondylia* sp. which was causing damage to brinjal flowers as well as fruits resulting in a yield loss upto 5 per cent.

During November–December, 1983 the gallmidge was found damaging the flower buds, flowers, developing ovary and fruits of brinjal. The damage was severe and about 60-80 per cent flowers were damaged. The fruit damage was only 2-3 per cent. When flower buds were attacked the stamens and pistil degenerated leading to no fruit formation. Damage on developing fruits resulted in distortion and crackings along the inner side of the curve rendering the fruits unfit for marketing. The specimens of the midge infesting different plant parts were reared and identified as *Asphondylia* sp.

The field collected midge maggots were found heavily parasitized by *Eurytoma* sp. (Hymenoptera : Eurytomidae). The extent of parasitization ranged from 8 to 15 per cent.. *Eurytoma* spp. are common parasites known to parasitize Diptera, Coleoptera, Lepidoptera and Hymenoptera (ASKEW, 1971). Earlier *Eurytoma dentata* Mayr. has been reported on *Asphondylia sarothamni* Loew in Germany (OTTEN, 1940) and Belgium (CREVECOEUR, 1950) and on *A. coronillae* Vallot in Italy (FAGGIOLI, 1939). *Eurytoma albipes* Ashmead was found parasitizing *Asphondylia helianthiglobulus* Osten-Sacken in America (BRELAND, 1939; BUGBEE, 1951). In India, *A. sesami* Felt. infesting *Sesamum indicum* Linn. has been reported to be parasitized by *Eurytoma dentipectus* Gahan (MANI, 1973) *E. nesiotes* Crawford (TIWARI, 1974) and *E.* sp. MATHUR & VERMA, 1973). The present report is the first record of *Eurytoma* sp. as a larval parasite of *Asphondylia* sp. infesting brinjal.

Contribution No. 131 84 of Indian Institute of Horticultural Research, Upper Palace Orchards, Bangalore.

Fig. 1. Adult male of *Asphondylia* sp.

Fig. 2. Adult of *Eurytoma*

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EFFECT OF SOIL NUTRIENTS AND VARIETAL REACTION TO THE POPULATION BUILD-UP OF BROWN WHEAT MITE, *PETROBIA LATENS* (MULLER) ON WHEAT

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Out of six micronutrients and 3 macronutrients applied to soil (loamy sand) in seed-furrow, zinc (zinc sulphate), boron (boric acid) and phosphorus (super phosphate) @ 10 kg/ha, 10 kg/ha and 40 kg/ha respectively, were found to be highly effective in keeping mite population low on a susceptible variety of *durum* wheat, *Raj 911* whereas, iron (ferrous sulphate) @ 15 kg/ha, favoured pest multiplication. In the second trial of 74 wheat entries, screened to see their reactions, none was found free from mite infestation. However, 8 entries *viz., MP 213, C 306, H 208, HD 2255, N 59, NI 5439, NI 7862* and *UPT 75233* arranged in ascending order of their resistance were observed least suscepetible.

(Key words: brown wheat mite, *Petrobia latens* (Muller), soil nutrients, varietal reaction).

INTRODUCTION

The brown wheat mite, *Petrobia latens* (M.) although occurs in several countries (PRITCHARD & BAKER, 1955), in India, it has been reported as an important pest of wheat and barley, particularly in the rainfed growing tracts of the country (BINDRA & KITTUR, 1961; MENON & GHAI, 1968). The typical damage symptom of the mite is, that on account of sap sucking, the leaves become chlorotic and start drying from tip backwards.

Various agronomical practices like late sowing, deep ploughing and crop rotation have been found effective in minimising the incidence of mite (CHU *et al.*, 1961) whereas the population in nitrogen applied plots has been reported to increase over the other nutrients (DOVAL *et al.*, 1974). The foliar spray of dimethoate (DEOL & SANDHU, 1976) and formothion (BHATIA *et al.*, 1976) have shown good results in keeping the mite under check. Further more, a number of wheat varieties have been screened, but none could be evolved resistant (VYAS *et al.*, 1973), so far.

Literature showed that no adequate work has been aken up to study the effect of soil nutrients particularly, the micronutrients on the population build-up of brown wheat mite. Therefore, the field tests were carried out to evaluate the effectiveness of both macronutrients (NPK) and micro (trace) nutrients in relation to the host-plant physiology. In addition to this, attempts were also made to throw light on the categorisation of wheat varieties not only on the basis of density of mites (as the earlier worker's did) but characteristic damage symptoms observed on each entry during the mite sampling.

MATERIALS AND METHODS

A field-plot trial was laid out in a randomised block design with ten treatments including untreated check at Agricultural Research Station, Durgapura, raipur (Raj.) during *rabi* 1980. Each treatment was replicated thrice. The plot size was kept 1×2m. Variety *Raj 911* was preferred for planting as *durums* are found compartively more susceptible than *aestivums*. All nutrients were applied in seed-furrow except nitrogen (urea) which was mixed in soil before drilling the seed into plot. For recording population of mite, two random spots of half meter crop row length were ear-marked in each plot. In all, three population counts were made during the crop season as shown in Table 1. In mite sampling the author followed the technique developed by KHAN *et al.*, (1978). In this method four microscopic slides each measuring 2.5 × 7.5 cm were smeared with glycerine on one side and than placed in four distinct grooves of equal size already made on a piece of thermocole sheet. All the plants of ear-marked units were gently tapped to dislodge the mites over the glycerine smeared slides and hence two such samples of mites were drawn in each plot at each count. Therefore, the total number of mite tapped in this way on each sample constitutes an area of 75 cm^2 (area of four slides) but in the present investigation the population is expressed for 10 cm^2 area per treatment. So, having pooled data for the corresponding number of mites of each treatment, the statistical analysis was done with the help of square root transformation.

In the second trial of 74 wheat entries, each was sown in a single row length of 200cm. Regarding the population of mite and injury symptoms, the crop of one meter row length was ear-marked in each entry leaving only half meter on each end of the row. The two samples of mite, each consisting of four glycerine smeared slides were drawn from these ear-marked units. In all four counts were made, the first was held on 31st January, when the mite began to appear followed by 17 February and then on 9 and 21st March, 1980. At each count the population of mite was taken into consideration for 10 cm^2 area instead of 75cm^2. At the same time the injury symptoms were observed on the plants of ear-marked units as a whole and leaves in particulr. At the time of peak incidence (9 March), since varieties could clearly be distinguished from one another with regard to damage symptom, they were all grouped into the different grades of susceptibility as given in Table 2.

RESULTS AND DISCUSSION

Table 1 shows that in general the mite population was found low in all the nutrient applied plots except ferrous nutrient as compared to untreated check. Throughout the observation period i.e. from appearance to peak, the lowest population was recorded from the plots treated with zinc followed by those with boron and phosphorus. In the case of ferrous nutrient the population was found to remain statistically higher over rest of the nutrient applied plots and it was followed by nitrogen. The other nutrients, although gave different responses with regard to the population level of mite, from the view point of effectiveness all were almost at par.

As regards the lowest mite population in zinc applied plots, phytotoxicity may be one of the factors as it was observed, although in later stages of the crop. The toxicity of the zinc to the mite was, however, not seen but it was an assumption based on the earlier findings of REED (1942) who reported it to be toxic to the plants. So keeping this background it was thought that mite also did not prefer to feed upon zinc applied crop. For the effectiveness of boron, the present finding is in agreement with RAJA RATNAM & HOCK (1975) who have advocated that the population of red spider mite, *Tetranychus* sp. was found high on oil palm seedlings where little or no boron was applied to the soil. Low mite population in phosphorus treated plots may be as a result of alteration in nitrogen balance as it has

TABLE 1. Effect of mineral nutrients on mite population recorded per 10 cm² area.

Sl. No.	Treatments	Source of nutrient	Dose kg/ha	Population recorded on			Population mean for 10 cm² area
				31.1.81	17.2.81	9.3.81	
1.	Zinc	Zinc sulphate	10 kg	*1.98 (3.92)	5.25 (27.56)	15.56 (242.11)	91.19
2.	Boron	Boric acid	10 kg	2.30 (5.29)	6.27 (39.31)	16.04 (257.28)	100.62
3.	Copper	Copper sulphate	5 kg	2.94 (8.64)	8.13 (66.09)	18.29 (334.52)	136.42
4.	Manganese	Manganese sulphate	10 kg	2.94 (8.64)	6.47 (41.86)	18.30 (334.89)	128.46
5.	Molybdenum	Ammonium molybdate	1 kg	3.50 (12.25)	7.45 (55.50)	18.75 (351.56)	139.77
6.	Iron	Ferrous sulphate	15 kg	5.25 (28.62)	14.20 (201.64)	20.75 (430.56)	220.27
7.	Nitrogen	Urea	80 kg	4.92 (24.20)	9.70 (94.02)	19.00 (361.00)	159.76
8.	Phosphorous	Superphosphate	40 kg	3.64 (13.25)	6.04 (36.48)	16.19 (262.11)	103.95
9.	Potash	Potassium oxide	20 kg	3.39 (11.49)	6.94 (48.16)	16.77 (281.23)	113.63
10.	Untreated control	—	—	4.81 (23.13)	12.29 (151.04)	19.38 (375.58)	183.25
	SEM ±			0.17	0.23	0.22	
	C D at 5%			0.50	0.68	0.66	

* Square root values. Figures in parenthesis are corresponding number of mites mite population

TABLE 2. Varietal performance based on the density of mite population and leaf damage symptoms.

Variety	Mite population per 10 cm² area	Characteristic damage symptoms appeared on leaves.	Pefrormance
C 306, HB 208, HD 2255, MP 313, N 59, NI 5439, 7862 & UPT 75233	(1—25)	White irregular spots on leaves resulting to stippling discolaration (Slightly attacked)	Least susceptible
APAU 1560, CC 464, DWR 6, DL 20-9, HB 340, 501, 600, HD 1982, 2135, 2233, 2251, 2270, 2274, 2285, 4530, HI 617, 8093, HS 86, 1079-9 (Girija) HUW 37, HW 517, 563, IWP 72, K 7402, 7503, 7513, Kalyan Sona, MACS 9, NG-14-4-1-10, NI 7888. 7895, Raj 1482, Shailza, Himani, TL 314, NI 7440, VL 421, 456, VW 53, WG 1809, WH 147, 261, 269, WL 711 & 2217	(26—150)	Yellowish regular spots on leaves resembling to chlorosis with sickly appearance, (Fairly attacked).	Susceptible.
DWR 21, HB 602, HD 2189, 2278, 4502, HI 784, 8062, 8078, HP 1327, HS 84, 144, 146, HUW 7, 100, HW 502, 647, 657, LOK 1, 7861, 7891, & Sonalika.	(above 150)	Bronzing of almost complete lower leaves & strarts drying from tip backwards. (Heavily attacked).	Most susceptible.

been observed that when phosphates are in abundance in root medium of the plant, the absorption of inorganic nitrogenous compounds get depressed (NIGHTINGALE, 1942).

On the other hand mite population was recorded significantly higher in ferrous treated plots over the rest of the nutrient except nitrogen and untreated check plots in the beginning. The cause of highest population in ferrous nutrients treated plots, throughout the crop season was attributed to its little mobility from older to younger leaves, which in course of feeding would have been helpful in promoting the population of mite, more on lower than upper leaves. Similarly the population of mites obtained was higher in nitrogen applied plots over other nutrients except ferrous. Moreover, there was no significant difference in population levels between the nitrogen applied plots and untreated check except on 17 Feb. when the population was recorded significantly low. This suggests that mite population was, although almost at par with untreated check, did not increase statistically over the untreated check as reported by TANDON (1973) and DOVAL *et al.* (1974) that higher insect-mite pest incidence has a direct correlation with high amount of nitrogen input. This discrepancy may be attributed to the differences in type of soil, clay fraction and pH where

mite has to shelter for most of the time.

Regarding the varietal resistance, none of the entries was found resistant. However, out of 74 entries, 8 were found to be least susceptible, 45 susceptible and 21 most susceptible having the population range from 1–25, 26–150 and above 150 mites per 10 cm^2 area, respectively. With respect to injury symptoms, all the varieties in beginning showed more or less small dot-like whitish irregular spots on the lowermost leaves of the plant which later on converted into large yellowish regular spots in most of the varieties. Furthermore, each variety could easily be distinguished from one another at the time of peak incidence. For example in case of most-susceptible variety the lower leaves not only starts drying from tip backwards but turned to bronzing in colour. At the time of last sampling (22 March) the population was found to decline sharply. Earlier workers, however, have screened a large number of entries/varieties (VYAS *et al.*, 1973; ANONYMOUS, 1976) but all were found to be involved in light to severe foliage incidence. VYAS *et al.* (1973) while categorising the varieties into different grades of susceptibility, emphasised that in the category of least susceptible, the population of mite, may reach upto 1.0 mite per cm^2 area whereas, in the present test, it was observed that when the average population of mite reaches beyound 25 mite per cm^2 area, the variety starts exhibiting white or pale yellow irregular spots (stippling), particularly on lower leaves. Hence, such varieties having crossed the average population from .25 mite per cm^2 area coupled with the damage symptom as described above, may therefore, be identified as susceptible instead of least susceptible.

It was evident from the above discussion that population of brown wheat mite was found to be under control with the soil application of micro (trace) nutrients, particularly zinc and boron. Therefore, in loamy sand oil (pH 8.2) where zinc (0.5 ppm) and boron (0.7 ppm) are not present to an acceptable limit, the additional quantity of 10 kg/ha of each, may be applied at the time of sowing. The application of ferrous nutrient would not be desirable as it has shown the tendency for enhancing the rate of reproduction in mite.

In conclusion, it would not be out of place to mention here that though the tests are preliminary, the efforts have been made for the first time for categorisation of wheat varieties into different grades of susceptiblity not only on the basis of density of mite population but leaf damage symptoms as well. The specific damage symptoms observed on leaves could not exclusively be correlated with the fixed number of mite counts because the population fluctuations, in fact depend upon the prevailing climatic conditions. Therefore, the author wishes that during varietal screening tests, this hasto be taken into consideration which would aid in mite population management.

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HOST PREFERENCE OF SORGHUM EARHEAD BUG, *CALOCORIS ANGUSTATUS* LETHIERRY (HEMIPTERA:MIRIDAE)[1]

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Ten common host plants of sorghum earhead bug, *Calocoris angustatus* Leth. namely, grain sorghum *(Sorghum bicolor* (L.) Meench), fodder sorghum *(S. bicolor)*, pearl millet *(Pennisetum typhoides* Stapt. Hubb), Italian millet *(Setaria italica* Beauv.), finger millet *(Eleusine coracana* Gaertin), little millet *(Panicum miliare* L.), maize *(Zea mays* L.), grass (F1 of *Pennisetum perpurium* L. × *P. typhoides*), sugarcane *(Saccharum officinarum* L.), *hariyali (Cynadon dactylon* (L.) Pers.) were evaluated for their suitability as food under field conditions. The maximum population (84.55—85.09 bugs three rows) was recorded on grain sorghum followed by fodder sorghum (13.49—15:57 bugs/three rows) and maize (2;00—2.78 bugs/three rows). Maximum number of nymphs survived on grain sorghum (92 per cent) followud by fodder sorghum (80 per cent and little millet (80 per cent). Mortality of nymphs was more on maize, sugarcane, Italian millet and grass; minimum developmental period noticed was 9.7±0.674 day in males and 10.2±0.788 days in females. Grain sorghum proved to be best host as compared to other hosts as it gave higher adult weight and size, compared to other hosts. Among all the hostplants tried the bugs oviposited only on sorghum earheads

(Key words: host preference, sorghum earhead bug, *Calocoris angustatus)*

INTRODUCTION

The pest status of a particular insect depends on its ability to breed on a variety of host plants, its fecundity, comparative growth rate, population dynamics and distribution (ANANTHAKRISHNAN, 1977). Sorghum earhead bug, *Calocoris engustatus* Leth. is one of the key pests of sorghum (SHESHU REDDY & DAVIES, 1979) and is known to attack 16 plant species (HIREMATH, 1981). Since the bug is polyphagous, the knowledge of its most pereferred host is essential for its economic management.

MATERIALS AND METHODS

For the purpose of studying the incidence, eight common host plants (Table 1) of the bug were either sown or planted in five rows in 5×3m plot to have 50 per cent synchronized flowering during 1978 and 1979 *Kharif* season in Agricultural College Farm, Dharwad. The randomised block design with three replications was followed. All the package of practices were followed except the plant protection measures. The population of bugs from all the earheads/tassels of middle three rows in each plot was recorded at weekly interval. The mean number of bugs of all the observations was used for comparing preference to different hosts.

In addition to the eight hosts, *hariyali* (*Cynadon dectylon* (L). Pers.) and sugarcane

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(Saccharum efficinarum L.) were also included for the purpose of studying the effect of host plants on the development of the bug. The development of bug was studied by enclosing 25 freshly emerged first instar nymphs on each host by cloth cage (HIREMATH, 1981). Observations were taken daily on the survival and development till all the surviving nymphs reached adult stage. Maximum length, width and weight of these adults recorded after anaesthetising them with chloroform within 24 hrs of their emergence.

The ovipositional preference of the bugs was studied by enclosing 10 pairs of freshly emerged adults on the inflorescence of these hosts under caged condition. There were three replications. Ovipositional preference was assessed based on the number of nymphs that emerged from the caged host plants. The emerged nymps were removed daily and their number recorded. The plants were kept under observation till 15 days after death of the adults.

RESULTS AND DISCUSSION

Incidence of bug: Results obtained in two years revealed that the population of bugs was highest on the grain sorghum

TABLE 1. Incidence of sorghum earhead bug, *Calocoris angustatus* Lethierry on different host plants durlng *Kharif* 1978, 1979 at dharwad.

Host plant	Geno-type	population of bugs 1978	1979
Grain sorghum *bicolor* (L.) Mench.)	CSH—5	9.18* (85.09)	9 8 (84.55)
Fodder sorghum *S. bicolor*	J-set—3	4.86 (15.57)	3.78 (13.49)
Pearl millet *(Pennisetum typhoides* Stapt. Hubb)	BJ—104	1.00 (0.00)	1.00 (0.00)
Italian millet *(Setaria italica* Beauv.)	K-121—1	1.00 (0.00)	1.00 (0.00)
Finger millet *(Eleusine coracana* Gaertin.)	Indaf—5	1.28 (0.67)	1.47 (1.29)
Little millet *(Panicum miliare* L.)	Local	1.00 (0.00)	1.00 (0.00)
Maize *(Zea mays* L.)	Deccan	1.66 (2.00)	1.87 (2.78)
Grass (F1 of *Pennisetum perpurium* L.) and *P. typhoides)*	Kamadhenu	1.00 (0.00)	1.00 (0.00)
SEM		0.48	0.33
C D at 5%		1.45	0.98

* $\sqrt{X + 1}$ Values and actual values with in the parenthesis.

TABLE 2. Host preference based on nymphal duration, weight and body size of adult of *Calocoris angustatus* Leth.

Sl. No.	Hosts	Survival %	Nymphal duration (days)		Weight of adults (μg)		Adult size (mm)			
							Length		Width	
			Male	Female	Male	Female	Male	Female	Male	Female
1.	Grain sorghum	92	9.7±0.674	10.2 ±0.788	48.4±6.57	61.9±2.08	4.80±0.42	5.40±0.52	1.11±0.22	1.95±0.16
2.	Fodder sorghum	80	9.9±0.737	11.10±0.567	47.7±5.01	61.8±5.99	4.05±0.16	5.00±0.62	1.17±0.24	1.87±0.32
3.	Finger millet	68	11.8±0.632	12.2 ±0.424	23.2±2.57	42.5±4.33	4.15±0.34	5.00±0.00	1.00±0.21	1.50±0.41
4.	Pearl millet	68	11.7±0.316	12.4 ±0.699	44.1±2.42	52.3±3.13	4.10±0.21	4.40±0.21	0.97±0.79	1.00±0.00
5.	Little millet	80	16.0±0.471	16.3 ±0.675	32.9±4.53	45.9±6.38	4.12±0.32	5.00±0.23	1.07±0.17	1.10±0.21
6.	Hariyali	40	16.5±0.850	17.6 ±0.516	26.6±2.58	37.5±3.86	3.85±0.24	4.40±0.52	0.95±0.10	1.10±0.21

with 85.09 bugs during 1978 and 84.55 during 1979 (Table 1) indicating the sorghum was the most preferred host. Bugs were not found on little millet, pearl millet and Italian millet.

Development of bugs on different hosts: The influence of different host plants on the development of bugs was assessed by their survival, nymphal duration, adult weight and adult size (Table 2).

a) *Survival of bug*: Out of 10 hosts included in the study, the first instar nymphs reached adult stage only in grain sorghum, fodder sorghum, finger millet, pearl millet,little millet and *hariyali*, The nymphs failed to develop on maize cobs, maize tassels, inflorescence of Italian millet, grass and sugarcane. Present findings differ from the reports of BALLARD (1916) and NAYAR *et al.* (1976) who reported sugarcane and maize as alternate hosts. Results indicate that the maximum number of (92 percent) of adults emerged on sorghum earhead (Table 2).

b) *Nymphal duration*: From Fig. 1 it is evident that the duration required by the nymphs to become adult males and females was 9.7±0.674 and 10.20±0.788 days on grain sorghum which was minimum among different host plants tested.

c) *Adult weight*: The host plants on which pre-imaginal stages developed, influenced the weight of adult bug (Table 2). The weight of adult male bug was minimum when reared on finger millet (23.20±2.37μg.). Simillarly, the weight of adult females was minimum when reared on *hariyali* (37 50±3.86 μg).

d) *Adult size*: Length and width of the adult bugs of both sexes differed due to the influence of pre-imaginal food. Size of the bug increased in case of pre-

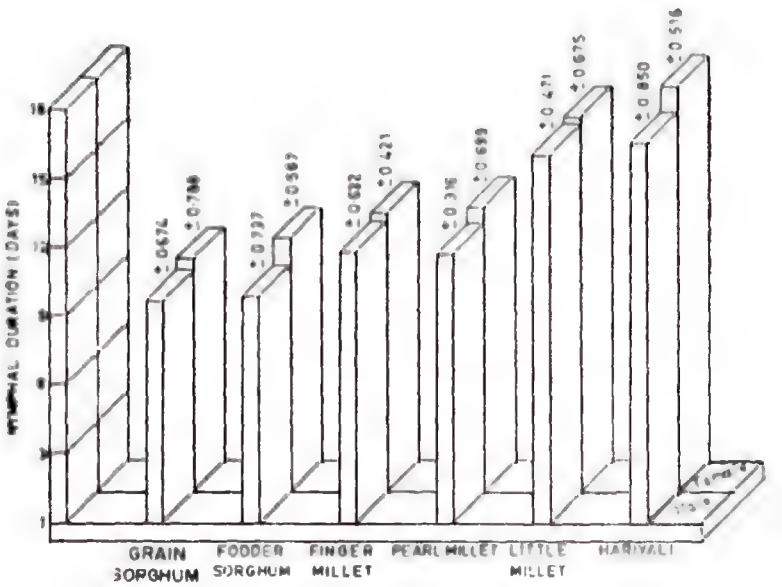

Fig. 1. Effect of host plants on development of *Calocoris angustatus* nymphs.

ferred hosts. Maximum size was observed in case of adult males (4.80 ± 0.42 × 1.11 ± 0.22 mm) and adult females (5.40±0.52 × 1.95±0.16 mm). Minimum size was observed in case of adult males (3.85±0.24 × 0.95mm) and adult females (4.440±0.52 × 1.10±.21mm) when reared on *hariyali*.

Ovipositional preference: Nymphs emerged normally from the earheads of grain sorghum (2059.33) and fodder sorghum (1595.67). Nymphs did not emerge from the earheads of pearl millet Italian millet, finger millet, little millet, *hariyali*, sugarcane and maize indicating that these host plants are not preferred for oviposition. To confirm the same, 100 spikelets from top middle and bottom portions of earheads of these hosts examined for oviposition but no eggs were noticed on any of these hosts.

Sorghum attracted more number of bugs under natural conditions. Moreover, under forced situation (when enclosed in the cloth cages) grain sorghum proved to be the most preferred host with least nymphal duration (Fig. 1), maximum survival and increased adults weight and adult size. It is important to note that fodder sorghum was preferred next to grain sorghum indicating the preference to different sorghum genotypes as reporeed by HIREMATH (1981). The development of the bug on pearl millet, finger millet, little millet and *hariyali* indicated only nymphal and adult stages of the bug can develop and thrive on these host plants when sorghum earhead is the only part used for oviposition.

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BRIEF COMMUNICATIONS

FORKED SENSILLUM ON THE ANTENNA OF *OPISINA ARENOSELLA* WALKER (LEPIDOPTERA : CRYPTOPHASIDAE)

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Scanning electronmicroscopic studies on the antenna of the black headed coconut caterpillar, *Opisina arenosella* revealed that, in addition to the five types of sensilla noted under light microscope, basiconic sensillum appeared some times forked.

(Key words: black headed caterpillar, *Opisina arenosella*, scanning electron microscopy, forked basiconic sensillum)

Our previous light microscopic studies on the antennal sensilla of the coconut leaf eating black headed caterpillar *Opisina arenosella* Walker (Lepidoptera : Cryptophasidae) showed the presence of five types of sensilla : coeloconic, basiconic, trichoid, styloconic and chaetica (JAYAPRAKASH & PRABHU, 1986) showing definite number and arrangement on the antennae. A scanning electron microscopic study of these sensilla has subsequently been carried out, the results of which are reported here.

For scanning electron microscopy, the antennae of newly emerged adults were fixed in 70% ethyl alcohol and washed several times in 70% ethyl alcohol till no more dust particles remained on the antennae. The antennae were subsequently air dried and fixed on stub and gold-coated (120-150 nm thickness) in an ion coater and observed through Hitachi S 145-A scanning electron microscope. The five types of sensilla observed with light microscope viz., sensilla coeloconica, sensilla chaetica, sensilla styloconica, trichoid sensilla and basiconic sensilla were also clearly distinguishable under the scanning electron microscope, in greater surface detail. In addition certain basiconic sensilla were occasionally distinguishable, which were forked at the distal end (Fig. 1).

Forked sensilla have been occasionally observed in some other insects also where they have usually definite number and arrangement and appeared to be a distinct category. For example, in the tarsi of female black fly *Simulium venustum* the ventral surface of the most proximal tarsomere of each mesothoracic leg had approximately 60 bifurcate sensilla, with specific structure and arrangement and were supposed to be contact chemosensilla which secondarily acquired an olfactory function (MC IVER *et al.*, 1980). Bifurcate peg sensilla are known from the coleopteran *Monochamus* species (DYER & SEABROOK, 1975), in thrips (SLIFER & SEKHON, 1974) and in scorpionflies (SLIFER, 1975). The bifurcate basiconic sensilla reported in the present study however do not appear to represent a distinct type of sensillum but only a variant of the basiconic sensillum.

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Scanning electron micrograph of antennal segment of *Opisina arenosella* to show the forked basiconic sensillum (arrow).

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NEW GENUS AND NEW SPECIES OF GALL MITES (ERIOPHYIDAE : ACARI) FROM TAMIL NADU

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The paper presents descriptions of one new genus and three new species of eriophyid mites. They are *Hemiscolocenus rares* gen. et sp. nov., *Abacarus foliavagrans*, sp. nov. and *Aceria alangiae* sp. nov.

(Key words: Eriophyidae; *Hemiscolocenus : Abacarus, Aceria)*

INTRODUCTION

During the course of collection and study of phytophagous mites in the Alagarmalai area of Madurai district several new mites were encountered. In this paper the descriptions and sketches of one new genus and three new species are presented.

The types and paratypes slides are deposited in the Department of Agricultural Entomology collections, Agricultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore-641 003, India. All measurements given are in micrometers.

Hemiscolocenus, gen, nov.

This genus is allied to *Scolocenus* Keifer (1962) and resembles it by the expanded dorsal shield, dorsal tubercles and setae moved forward; rostrum projecting down with short form oral stylet, lateral abdominal setae situated under expanded rear angle of shield and female genitalia situated near coxae. It is differentiated from *Scolocenus* by the more elongated anterior lobe of shield which nearly covers the rostrum; lateral abdominal setae on elongated tubercles; dorsal thanosome with ridge; tergites with lateral spines and absence of the anterior lateral abdominal expansion and spines. It is also differentiated by the presence of the femoral setae on the legs in the inner lateral position; the femoral spines and the presence of all three setiferous coxal tubercles.

Body broad in the anterior shield region, abruptly narrowing down posteriorly. Shield irregularly rounded in dorsal view with ridges and furrows; the anterior lobe over rostrum acuminate and project down covering the rostrum; shield laterally expanded and covers the base of legs; dorsal tubercles well ahead of posterior shield margin, prominent, dorsal setae pointing forward. Rostrum of normal size, pointing downward with short form oral stylets. Coxae with all three setiferous tubercles. Legs with all usual setation; femora with a ventral broad spine like projection and the femoral setae on the inner lateral position; featherclaw simple. Abdomen broad anteriorly, abruptly narrowing down posteriorly; tergites ending laterally into broad spines; lateral abdominal setae

present under expanded rear angle of shield on elongated tubercles; first ventral seta absent; second and third ventral setae present; caudal seta present. Female genitalia near coxae with scorings on the coverflap.

Type species: *Hemiscolocenus rares*, sp. nov.

1. Hemiscolocenus rares, sp. nov. (Fig. 1)

Female: 190 long, 70 thick at the anterior end; 80 broad at shield region; rostrum 35 long, down curved with short form oval stylet, antapical seta 5 long; shield 80 wide, 80 long, with fine wavy lines throughout the shield area, with broad lobe like shield area in the middle; dorsal tubercles away from rear shield margin 22 apart, tubercles 7 long, dorsa

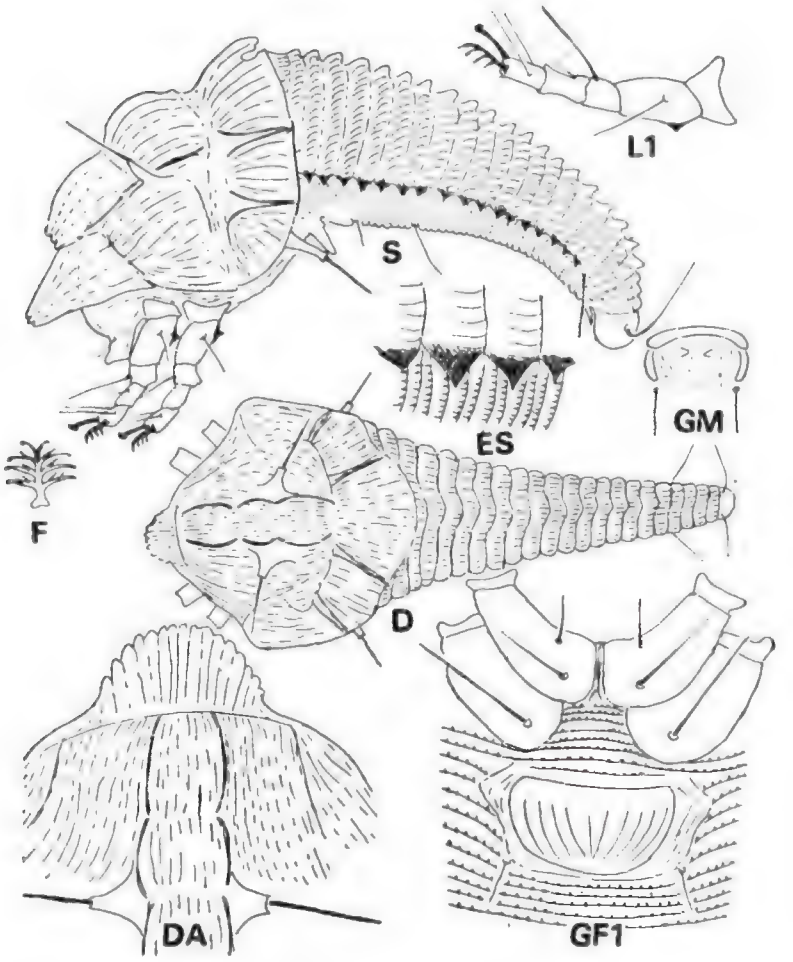

Fig. 1. *Hemiscolocenus rares* sp. nov.

Abbreviations used: AP 1—Internal female apodeme; CS—Side view of cauda; CV—Ventral view of cauda; D—Dorsal view of mite, ES—Side skin structure; F—Feather claw; GFI—Female genitalia and coxae from below; GM—Male genitalia; L1—Left foreleg, L2—Left hind leg; S—Side view of mite.

setae 10 long, pointing upward and forward. Rear lobe of shield free, covering the first few abdominal tergites. Foreleg 30 long, tibia 5 long, tibial seta 4 long, tarsus 5 long, claw, curved and broadly knobbed at tip: featherclaw simple, 4 rayed; hind leg 28 long, tibia 5 long, tarsus 5 long; claw 5 long; all usual setation present on legs; femoral seta on the inner lateral angle, femora with a broad spine ventrally; coxae broadly joined, all three setiferous tubercles present, coxal area clear. Abdomen with tergal and sternal differentiation, about 45 sternites becoming broader posteriorly, 25 tergites ending laterally in broad spines; tergites and sternites with elongated microtuberculation; the abdominal rings narrowing down abruptly towards posterior end; dorsally with a ridge flanked on either side with shallow troughs; lateral abdominal setae present under the expanded rear angle of shield on elongated tubercles, tubercle 6 long, setae 8 long; first ventral seta absent second ventral seta 5 long; third ventral seta 12 long on ring 6 from behind; caudal seta 20 long, accessory seta absent; female genitalia near coxal base, 22 wide, 15 long, coverflap with 10—12 faint lines; genital seta 16 long just away from posterior border of genitalia.

Male: Similar in shape to female, 190 long, 80 wide, genitalia 18 wide, genital seta 8 long.

Types: A holotype slide with ♀♀; 5 paratype slides with ♂♂ and ♀♀, INDIA: TAMIL NADU : Madurai, Alagarmalai, 9. vi. 1984, M. Mohanasundaram coll. (No. 510) (TNAU), ex *Buettneria aspera* Colebr. (Tiliaceae)

2. Abacarus foliavagrans, sp. nov. (Fig. 2)

This species resembles *Abacarus ureutae* Keifer (1972) in its general shield pattern but differentiated from it by the non granular, coxal area, female genital coverflap with scorings in the distal half and the 4 rayed featherclaw.

Female: 170 long, 60 thick, light brown in colour, rostrum 15 long, evenly down curved, antapical seta 6 long; shield 53 wide, 38 long; median absent, admedians wavy and joined in the anterior and posterior ends, submedian forming a curved line on either side of shield and joined anteriorly with the admedians; sides of shield clear; dorsal tubercles at rear shield margin, 25 apart; dorsal setae 9 long pointing backward and outward. Foreleg 30 long, tibia 8 long, tibial seta 5 long, tarsus 5 long, claw 5 long, curved and knobbed tip; featherclaw 4 rayed; hind leg 28 long, tibia 7 long, tarsus 5 long, claw 5 long; coxae with all three setiferous tubercles, coxal area clear except for a strong line on either side in hind coxae. Abdomen with about 36 smooth tergites and 65 microtuberculate sternites; dorsum with a median ridge fading out posteriorly with two sub-dorsal troughs on either side; lateral seta 25 long on ring 12; first ventral seta 65 long on ring 24; second ventral seta 18 long on ring 40; third ventral seta 25 long on ring 5 from behind; caudal seta 70 long; accessory seta 2 long. Female genitalia 22 wide, 17 long; coverflap with 12–14 lines; genital seta 12 long.

Male: Not known.

Types: A holotype slide and 5 paratype slides, all with ♀♀ INDIA: TAMIL NADU: Madurai, Alagarmalai, 9.vi.1984, ex *Sterculia villosa*, Roxb. (Sterculiaceae) M. Mohanasundaram Coll. (No. 508) (TNAU). Mites are under surface leaf vagrants.

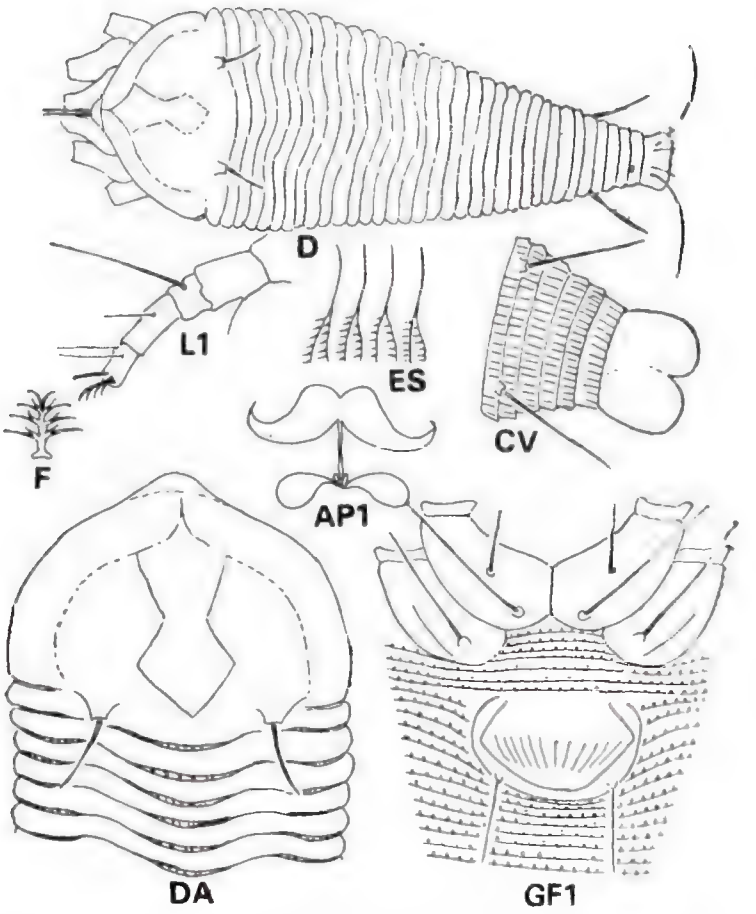

Fig. 2. *Abacarus foliavagrans* sp. nov. Abbreviations as in Fig. 1.

3. Aceria alangiae, sp. nov. (Fig. 3)

Female: White, worm like, 170 long 50 thick; rostrum 13 long, evenly down curved, antapical seta 4 long. Shield 30 wide, 22 long, without any lines; sides of shield clear; dorsal tubercles on rear shield margin, 15 apart dorsal setae 30 long, pointing backwards. Foreleg 23 long, tibia 4 long, tibial seta 3 long; tarsus 6 long, claw 5 long; featherclaw simple, 4 rayed; hind leg 20 long, tibia 3 long, tarsus 5 long; claw 9 long. Coxae with a clear sternal line all three setiferous tubercles present, coxal area clear. Abdomen with about 68-70 rings uniformly microtuberculate; lateral seta 5 long on ring 8; first ventral seta 32 long on ring 20; second ventral seta 5 long on ring 36; third ventral seta 16 long on ring 6 from behind; accessory seta 5 long. Female genitalia 20 wide, 12 long; coverflap with 8 longitudinal scorings; genital seta 2 long.

Male: Unknown

Types: A holotype slide and 4 paratype slides, all with ♀♀; INDIA: TAMIL NADU: Madurai, Alagarmalai; ex *Alangium*

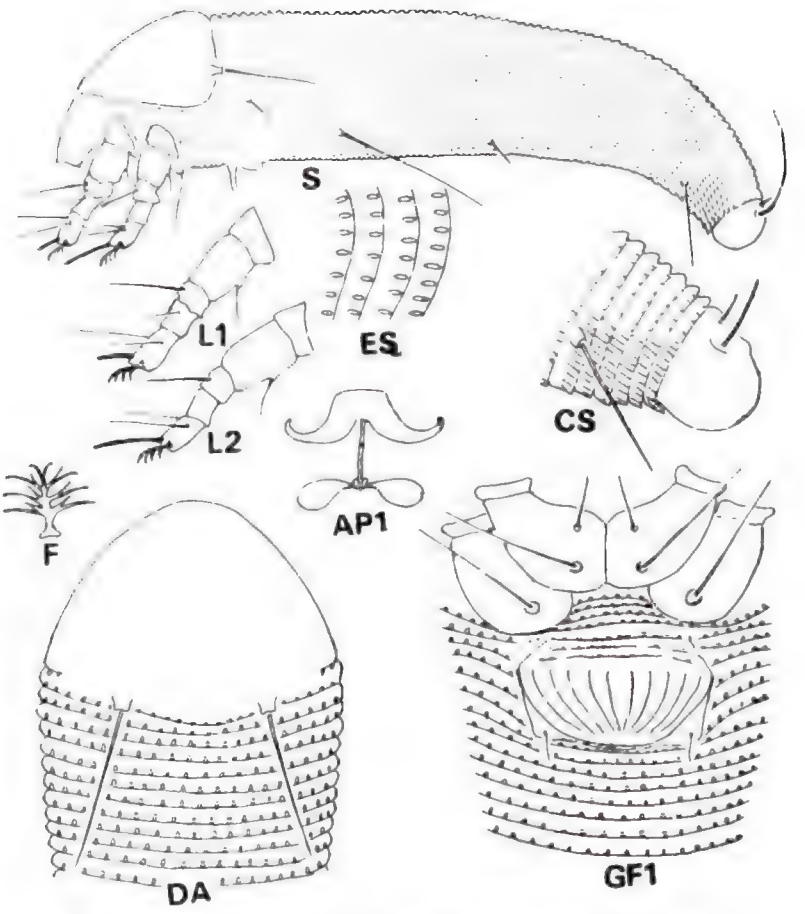

Fig. 3. *Aceria alangiae* sp. nov. Abbreviations as in Fig. 1.

sp. (Alangiaceae) 9.vi.1984. M. Mohanasundarm Coll. (No. 616) (TNAU). The mites produce erineum patches on both sides of the leaves.

Remarks: This species resembles *Aceria vriddhagiriensis* (Mohanasundaram 1981) in its clear shield area, and smooth coxal area but differentiated from it by the 4 rayed featherclaw, female genital coverflap with 10 lines and longer dorsal seta.

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CYTOGENETICAL STUDIES ON APHIDS (HOMOPTERA: APHIDIDAE) FROM INDIA: II. KARYOMORPHOLOGY OF FIVE SPECIES OF *MYZUS*

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The diploid number, morphology and behaviour of somatic chromosomes in embryos of apterous viviparous females of five species of *Myzus*, viz., *M. cerasi*, *M. formosanus*, *M. mumecola*, *M. persicae* and *M.* sp., have been studied. Except for the unidentified species of *Myzus*, all the species under report had $2n=12$ and the chromosome formulae suggested on the basis of the relative percentage lengths of individual pairs were $n=2M$ (Medium) + $2S$ (Short) + $2VS$ (Very Short) in *M. cerasi*, $n=1L$ (Long) + $1M$ + $2S$ + $2VS$ in *M. formosanus*, $n=1L$ + $1M$ + $3S$ + $1VS$ in *M. mumecola*, $n=2M$ + $2S$ + $2VS$ in *M. persicae* and $2n=10$, $n=2M$ + $3S$ in *M.* sp. There was indication of karyotypic variations in respect of both number and morphology of chromosomes in *M. persicae* occurring in the natural populations. The diploid number remaining the same, some variations in the chromosome morphology were also encountered in two clones of *M. formosanus* collected from two different host plants. Attempts have been made to make out cytological differences among the congeneric species under study and the possible mechanism of karyotypic evolution in this genus has been suggested.

(Key words: chromosomes, karyotypes, aphids, *Myzus*, mitotic behaviour, holokinetic chromosomes)

INTRODUCTION

In continuation of our cytogenetical studies on some Indian aphids (KHUDA-BUKHSH, 1980, 1982; KHUDA-BUKHSH & DATTA, 1978; KHUDA-BUKHSH & PAL, 1983 a, b, 1984 a, b, c; DATTA & KHUDA-BUKHSH 1980; PAL & KHUDA-BUKHSH, 1980, 1982, 1983, 1984, 1985), we intend to record the diploid number, behaviour and morphometrical data of chromosomes in embryonic cells of five species of *Myzus* belonging to the tribe Macrosiphini in the present communication.

So far as we are aware, among the five species, cytogenetical investigations on *M. cerasi* and *M. mumecola* had not been carried out earlier.

MATERIALS AND METHODS

Apterous viviparous females of five species of *Myzus*, viz., *M. cerasi* (Fabricius), *M. formosanus* Takahashi, *M. mumecola* (Matsumura), *M. persicae* (Sulzer) and *M.* sp. (?) were collected in and around Sonprayag and Trijuginarayan areas of the Garhwal Himalayas, U. P., India, from the host plants *Prunus* sp. (Rosaceae) *Impatiens* sp. (Balsaminaceae), *Prunus cornuta* (Rosaceae), *Nicotiana* sp. (Solanaceae) and *Gallium aprina* (Rubiaceae) respectively. The young embryos were squeezed out of the abdomen and were subjected to the citrate air-drying Giemsa stain schedule for the preparation of slides for cytological examination. diploid number in each species has been determined from the peak frequency in at least 50 well spread metaphase eomplements. Each chromosome of a complement was measured and identical ones were matched as homologous

TABLE 1. Mean Lengths in μm (M_1), Relative percentage Lengths (R_L) and Arbitrary Nomenclature (A_n) of chromosomes expressed as haploid set in five species of *Myzus*.

Sl. No. of Chrom.	*M. cerasi*				*M. formosanus*				*M. mumecola*				*M. persicae*				*M* sp.			
	M_1	±SE	R_L	A_n	M_1	±SE	R_L	A_n	M_1	±SE	R_L	A_n	M_1	±SE	R_L	A_n	M_1	±SE	R_L	A_n
1.	4.16	0.261	28.31	M	4.22	0.137	31.02	L	4.80	0.092	31.55	L	4.93	0.106	27.44	M	5.42	0.237	28.45	M
2.	3.58	0.188	24.37	M	2.83	0.169	20.80	M	3.52	0.189	23.14	M	4.19	0.095	23.32	M	4.61	0.273	24.19	M
3.	2.43	0.045	16.54	S	2.35	0.035	17.27	S	2.11	0.089	13.87	S	3.58	0.139	19.93	S	3.74	0.202	19.63	S
4.	1.91	0.181	13.00	S	1.91	0.272	14.04	S	2.04	0.103	13.41	S	3.49	0.157	13.86	S	3.17	0.205	16.64	S
5.	1.40	0.103	9.53	VS	1.29	0.102	9.48	VS	1.53	0.181	10.05	S	1.53	0.114	8.85	VS	2.11	0.134	11.07	S
6.	1.21	0.136	8.23	VS	1.00	0.102	7.35	VS	1.21	0.136	7.95	VS	1.18	0.182	6.57	VS	—	—	—	—
TCL =	14.69				13.60				15.21				17.96				19.05			

L = Long; M = Medium; S = Short; VS = Very Short; TCL = Total Chromosome Length.

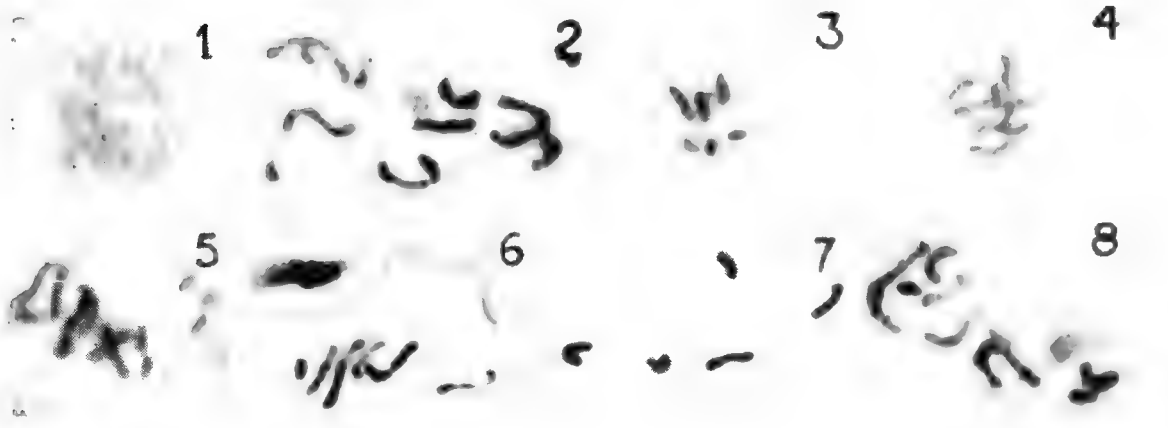
pairs. The relative percentage lengths (R_L) of each pair in the complement were obtained from the mean value of 10 complements (Table 1) and the idiograms of each species (Figs. 9—14) were prepared on the basis of their R_L. Chromosome formula of each species has been suggested as per our earlier papers (KHUDA-BUKHSH & PAL, 1984 a, c).

RESULTS

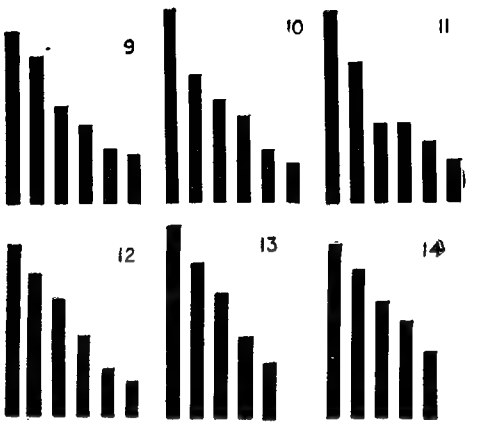
The mitotic behaviour in all the five species followed the orthodox holokinetic pattern as described for some other species of aphids earlier (KHUDA-BUKHSH, 1980; DATTA & KHUDA-BUKHSH 1980: KHUDA-BUKHSH & PAL, 1984 b, c).

The overwhelming majority of the diploid metaphase complements in *M. cerasi* (Fig. 1), *M. formosanus* (Fig. 2), *M. mumecola* (Fig. 4) and *M. persicae* (Fig. 5) contained 12 chromosomes while the same in *M.* sp. (Fig. 8) had 10 chromosomes. Therefore, $2n = 12$ was suggested for all except *M.* sp. which had $2n = 10$ chromosomes. In a few plates of *M. mumecola* (Fig. 3), there were 6 chromosomes which presumably represented haploid elements. On the other hand, although about 60% of the total number of 74 metaphase plates examined in *M. persicae* had 12 chromosomes, about 17% of the plates had 10 chromosomes (Fig. 6) and about 15% of the plates had 8 chromosomes. Interestingly, in one plate (Fig. 7), there were 5 elements, in another there were 4 and in two other plates there were 6 elements, all of which possibly represented haploid set of chromosomes. Thus, in different complements of *M. persicae*, 10 and 8 chromosomes occurred in quite a high frequency besides the 12 chromosomes present in the majority of them which has been suggested as the diploid number in this species.

The detailed morphometrical data of the individual pairs of chromosomes in these five species have been given in Table 1, and the idiograms (Figs. 9-14)



Figs. 1–8. Photomicrographs of metaphase complements showing 12 chromosomes in *M. cerasi* (Fig. 1), *M. formosanus* (Fig. 2); 6 and 12 chromosomes (Figs. 3 & 4) in *M. mumecola*; 12, 10 and 5 chromosames (Figs. 5–7) in *M persicae* and 10 chromosomas in *M.* sp.



Figs. 9–14. Idiograms based on R_L in *M. cerasi* (Fig. 9), *M. formosanus* (Fig. 10), *M. mumecola* (Fig. 11), *M. persicae* (Fig. 12) and *M.* sp. (Fig. 14). Fig. 13 represents 10-chromosome complement of *M. persicae* and inserted for comparison.

presented for overview comparison. From these, it would be revealed that although *M. cerasi*, *M. formosanus*, *M. mumecola* and *M. persicae* had $2n = 12$ chromosomes, a critical analysis of morphometrical data of individual chromosome pairs would show a considerable difference among them. Thus, the chromosome formulae were $n = 2M + 2S + 2VS$ in *M. cerasi*, $n = 1L + 1M + 2S + 2VS$ in *M. formosanus*, $n = 1L + 1M + 3S + 1VS$ in *M. mumecola* and $n = 2M + 2S + 2VS$ in *M. persicae*. Apparently, the karyotypes in *M. cerasi* and *M. persicae* looked somewhat similar while those of *M. formosanus* and *M. mumecola* were somewhat different in having a long 1st pair of chromosomes which had conspicuous size difference with the 2nd pair against a rather gradual seriation in the former two species. However, the karyotypes of *M. formosanus* and *M. mumecola* could be distinguished from each other by virtue of the size difference between the 2nd and 3rd pair which was quite palpable in *M. mumecola*, but less striking in *M. formosanus*. In the unidentified species of *Myzus*, the karyotype differed from the rest in having 10 chromosomes with gradually seriated chromosomes.

DISCUSSION

Eleven species including the unidentified one in the present study have so far been cytologically investigated, of which, *M. physocarpi* had $2n = 20$, *M. dianthicola* had $2n = 14$ and *M.* sp. had $2n = 10$ while all the rest had $2n = 12$ chromosomes (ROBINSON & CHEN, 1969; GUT, 1976; BLACKMAN, 1980; PAL & KHUDA-BUKHSH 1980; KUDHA-BUKHSH & PAL, 1983a; KULKARNI & KACKER, 1980). Therefore, the modal number in this genus seems to be 12 from which karyotypes of 10 and 14 in the stray species have been derived presumably by fragmentation and fusion of chromosomes. Chromosomal variation due to fragmentation/fusion has been particularly rampant in *M. persicae* as reported by various authors (COLLING, 1955; SUN & ROBINSON, 1966; BLACKMAN, 1971; BLACKMAN & TAKADA, 1977). In India, MISHRA & KURL (1979) reported the occurrence of $2n = 10$, 11 and 12 chromosomes in Jodhpur population while KULKARNI & KACKER (1980) reported $2n = 12$ chromosomes in the Solan, H. P. populations of the same species. The chromosome number and the karyotypic account given by KULKARNI & KACKER (1980) are in good agreement with the suggested karyotype of 12 chromosomes in *M. persicae* in the present study although these authors (KULKARNI & KACKER) did not mention of the other numbers. It would be of interest to critically study the individual clone of *M. persicae* from different geographical areas and different host plants to ascertain whether the aneuploid numbers occur as regular number in any clone, thus indicating a

possible bearing on host plant relationship. Incidentally, in our study, some karyotypic deviations in *M. formosanus* collected from a different host plant, *Alnus nepaliensis* could be brought out in that the 1st pair of chromosomes were distinctly smaller than their counterparts collected from *Impatiens* sp. under report, although the diplold number was same in both the clones. Distinct karyotypic differences in respect of both diploid number and morphology have also been observed by us in *B. helichrysi* collected from different host plants (PAL & KHUDA-BUKHSH, 1985). Clearly, a critical study of the karyotypic variations in different clones of the same species of aphids could lead us to some important clues in regard to host preferences.

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CYTOGENETICAL STUDIES ON APHIDS (HOMOPTERA : APHIDIDAE) FROM INDIA : III. KARYOMORPHOLOGY OF FIFTEEN SPECIES BELONGING TO THE TRIBE MACROSIPHINI

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Detailed karyomorphological data on chromosomes of fifteen species of aphids, namely, *Acyrthosiphon rubiformosanus, Aulacorthum solani, Eumyzus eastopi, E. impatiensae, Impatientinum asiaticum, Indoidiopterus geranii, Macrosiphoniella formosartemisiae, M. kikungshana, M. pseudoartemisiae, Metopolophium ignotum, M. sonchifoliae, Nasonovia (Kakimia) rostrata, Phorodon (Diphorodon) cannabis, Uroleucon fuscaudatus* and *U. longisetosus*, belonging to the tribe Macrosiphini have been presented along with the idiograms. An arbitrary chromosome formula based on relative genome lengths of individual pair was assigned for each species to have a general impression of the karyotypes. The modal number in the tribe Macrosiphini has been suggested from the available cytogenetic data in this tribe.

(Key words: chromosomes, karyotypes, karyomorphology, aphids, mitotic behaviour, holokinetic chromosomes, Macrosiphini)

INTRODUCTION

In continuation of our cytogenetical survey on some Indian aphids (KHUDA-BUKHSH, 1980, 1982; KHUDA-BUKHSH & PAL, 1983 a, b, 1984 a, b, c, 1985; PAL & KHUDA-BUKHSH, 1980, 1982, 1983, 1984, 1985 a, b), we intend to record in the present communication the detailed morphological data on chromosomes and the idiograms of fifteen species of aphids belonging to the tribe Macrosiphini, the diploid numbers of which save *Eumyzus eastopi* had earlier been reported by us (PAL & KHUDA-BUKHSH, 1980, 1982).

MATERIALS AND METHODS

The young embryos of apterous viviparous females of the fifteen species of aphids belonging to the tribe Macrosiphini collected from different host plants and localities of the North-West Himalayas (Table 1) were subjected to the citrate-air drying Giemsa stain schedule for studying their somatic chromosomes. The morphometrical data on chromosomes in these fifteen species were obtained and nomenclature suggested (Table 2) according to the procedures described in our earlier papers (KHUDA-BUKHSH & PAL, 1984 b, c, 1985). Idiograms (Figs. 1-15) were prepared depending on the relative percentage lengths of individual pairs of chromosomes in the fifteen species.

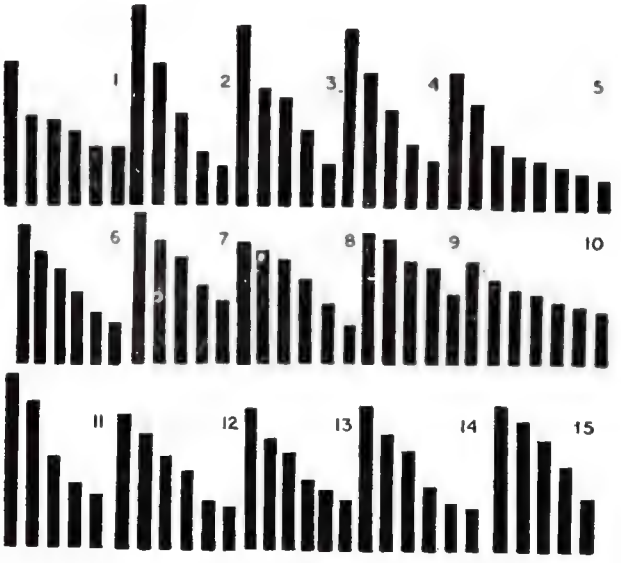
RESULTS AND DISCUSSION

The mitotic behaviour in all the fifteen species under study followed the typical aphid pattern as described for some other species of aphids earlier (DATTA & KHUDA-BUKHSH, 1980; KHUDA-BUKHSH & PAL, 1984 a, b).

Out of the fifteen species, *Aulacorthum solani, Eumyzus impatiensae, Macrosiphoniella formosartemisiae, M. pseudoartemisiae, Metopolophium sonchifoliae* and *Uroleucon longisetosus* had $2n = 10$,

Acyrthosiphon rubiformosanus, *Indoidiopterus geranii*, *Macrosiphoniella kikungshana*, *Nasonovia (Kakimia) rostrata*, *Phorodon (Diphorodon) cannabis* and *Uroleucon fuscaudatus* had $2n=12$, *Metopolophium ignotum* had $2n=14$ while *Impatientinum asiaticum* had $2n=16$ chromosomes. In the present study, two congeneric species each of *Eumyzus*, *Metopolophium* and *Uroleucon* and three congeneric species of *Macrosiphoniella* have been studied of which both the species of *Eumyzus* had $2n=10$ chromosomes with more or less similar karyotypes while two out of three congeneric species of *Macrosiphoniella*, viz., *M. formosartemisiae* and *M. pseudoartemisiae*, had a more or less similar karyotype of $2n=10$, but the other congeneric species *M. kikungshana* had $2n=12$ chromosomes, suggesting fragmentation of a long pair to give rise to the karyotype or else fusion of chromosomes leading to the origin of $2n=10$ from the $2n=12$ karyotype. Similar situation was also encountered in case of *Uroleucon fuscaudatus* ($2n=12$) and *U. longisetosus* ($2n-10$). However, *Metopolophinm ignotum* ($2n=14$) differed considerably from *M. sonchifoliae* ($2n=10$) possibly indicating the incidence of more fragmention/fusion than one in the origin of one karyotype from the other.

If the karyotypes of the different species in the tribe Macrosiphini showing the same diploid number were compared among the species having $2n = 10$, a gross similarity in the karyotypic pattern could be observed among *Aulacorthum solani* (Fig. 2), *Eumyzus eastopi* (Fig. 3), *E. impatiensae* (Fig. 4) and *M. sonchifoliae* in having a long 1st pair of chromosomes and also among *Macrosiphoniella formosartemisiae* (Fig. 7), *M. pseudoartemisiae* (Fig. 9) and *U. longisetosus* (Fig. 15) in having 1st two medium and last two short pairs (Table 2). Among the species having $2n = 12$, the karyotypes of *Acyrthosiphon rubiformosanus* (Fig. 1),



Figs. 1–15. Idiograms of the fifteen species of aphids listed in Tables 1 & 2 serially.

TABLE 1 List of species, their host plants, place of collection and chromosome formulae.

	Name of species	Host plant & family	Place of collection	$2n=$	n
1.	*Acyrthosiphon rubiformosanus* (Takahashi)	*Urtica dioca* (Urticaceae)	Srinagar, J & K	12	1M+5S
2.	*Aulacorthum solani* (Kaltenbach)	Unidentified	Trijuginarayan, UP	10	1L+1M+2S+1VS
3.	*Eumyzus eastopi* Maity & Chakroborti	*Prunus* sp (Rosaceae)	Do	10	1L+2M+1S+1VS
4.	*E. impatiensae* (Shinji)	*Impatiens* sp. (Balsaminaceae)	Do	10	1L+1M+2S+1VS
5.	*Impatientinum asiaticum* Nevsky	*Smilax* sp (Liliaceae)	Gourikund, UP	16	1M+3S+4VS
6.	*Indoidiopterus geranii* (Choudhuri *et al.*)	*Geranium* sp. (Geraniaceae)	Trijuginarayan, UP	12	2M+3S+1VS
7.	*Macrosiphoniella formosartemisiae* Takahashi	Unidentified (Compositae)	Rambara, UP	10	3M+2S
8.	*M. kikungshana* Takahashi	Unidentified (Compositae)	Trijuginarayan, UP	12	2M+3S+1VS
9.	*M. pseudoartemisiae* Shinji	*Artemesia scoparia* (Compositae)	Srinagar, J & K	10	2M+3S
10.	*Metopolophium ignotum* (Mordvilko)	*Deuetsia corymbosa* (Deuetziaceae)	Jamunetri, UP	14	7S
11.	*M. sonchifoliae* (Ray-Choudhuri *et al.*)	*Rubus ulmifolius* (Rosaceae)	Srinagar, J & K	10	1L+1M+3S
12.	*Nasonovia (Kakimia) rostrata* (David & Hameed)	*Strobilanthus* sp. (Acanthaceae)	Trijuginarayan, UP	12	2M+2S+2VS
13.	*Phorodon (Diphorodon) cannabis* Passerini	*Cannabis sativa* (Moraceae)	Do	12	2M+3S+1VS
14.	*Uroleucon fuscaudatus* (Chakroborti & Ray-Choudhuri	*Inula* sp. (Compositae)	Rambara, UP	12	2M+2S+2VS
15.	*U. longisetosus* Chakroborti & Verma	*Inula* sp. (Compositae)	Govindaghat, UP	10	3M+2S

L = Long; M = Medium; S = Short; VS = Very Short; UP = Uttar Pradesh; J & K = Jammu & Kashmir.

Indoidiopterus geranii (Fig. 6) and *Macrosiphoniella kikungshana* (Fig. 8) agreed in the general pattern although the size difference between 1st and 2nd pairs of chromosomes was more palpable in *A. rubiformosanus* than in the other two species. Gross karyotypic similarity could also be marked from the idiograms of *Nasonovia (Kakimia) rostrata* (Fig. 12), *Phorodon (Diphorodon) cannabis* (Fig. 13) and *Uroleucon fuscaudatus* (Fig. 14). However, there were considerable differences in the karyotypes of *Impatientinum asiaticum* (Fig. 5) and *Metopolophium ignotum* (Fig. 10) from the other members of the tribe Macrosiphini under report.

So far, cytogenetical data on some 220 odd species of the tribe Macrosiphini have accumulated (Fig. 16) (ROBINSON & CHEN, 1969; KUZNETSOVA & SHAPOSHNIKOV, 1973; GUT, 1976; BLACKMAN, 1980; MANNA, 1983; KHUDA-BUKHSH *loc. cit.*). The haploid numbers varied from $n = 2$ to 36 with a distinct peak at $n = 6$ represented by as many as as 112 species. The next peak was at $n = 5$ represented by some 56 species. Therefore, the present trend would indicate $n = 6$ and $2n = 12$ as the possible modal number of the tribe to which *A. rubiformosanus*, *I. geranii*, *M. kikungshana*, *N. (K.) rostrata*, *P. (D.) cannabis* and *U. fuscaudatus* under the present report belong.

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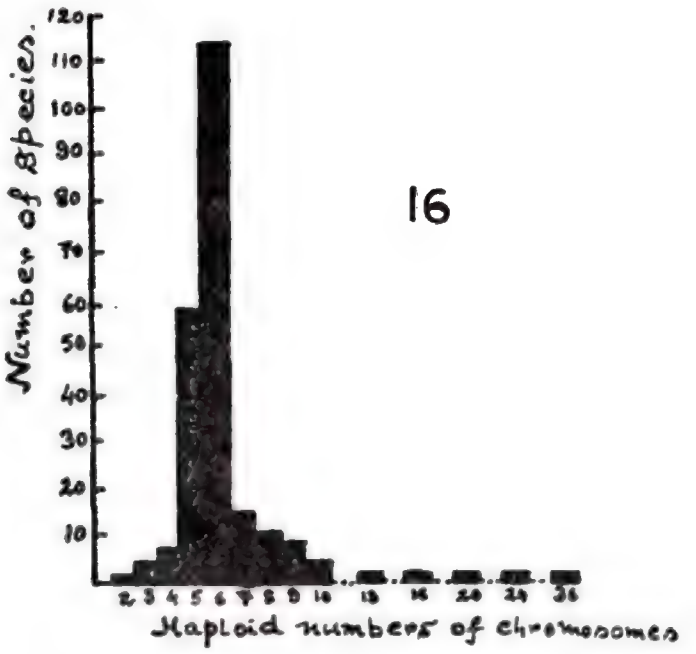

Fig. 16. Histogram showing the haploid numbers in the tribe Macrosiphini.

TABLE 2. Mean lengths in μm (M_1), Relative percentage Lengths (R_L) and Arbitrary nomenclature (A_n) of chromosomes in fifteen species of aphids. Data expressed as haploid set.

Name of species	Serial number of chromosome																					
	1			2			3			4			5			6			7			8		
	M_1	R_L	A_n	M_1	R_L	A_n	M_1	R_L	A_n	M_1	R_L	A_n	M_1	R_L	A_n	M_1	R_L	A_n	M_1	R_L	A_n	M_1	R_L	A_n
1. *A. rubiformosanus*	3.12	27.83	M	2.01	17.93	S	1.82	16.23	S	1.63	14.54	S	1.34	11.95	S	1.29	11.50	S	—	—	—	—	—	—
2. *Aula. solani*	5.93	37.84	L	4.15	26.48	M	2.78	17.74	S	1.67	10.65	S	1.14	7.27	VS	—	—	—	—	—	—	—	—	—
3. *Eu. eastopi*	4.22	33.35	L	2.88	22.76	M	2.62	20.71	M	1.85	14.62	S	1.08	8.53	VS	—	—	—	—	—	—	—	—	—
4. *Eu. impatiense*	6.63	34.21	L	4.99	25.00	M	3.79	18.98	S	2.59	12.97	S	1.96	9.81	VS	—	—	—	—	—	—	—	—	—
5. *Im. asiaticum*	4.20	25.78	M	3.13	19.21	S	2.01	12.33	S	1.70	10.43	S	1.48	9.08	VS	1.38	8.47	VS	1.30	7.98	VS	1.09	6.69	VS
6. *Indoi. geranii*	3.76	26.38	M	3.11	21.82	M	2.62	18.38	S	2.13	14.94	S	1.49	10.45	S	1.14	8.00	VS	—	—	—	—	—	—
7. *Macro. formosartemisiae*	3.16	28.40	M	2.62	23.77	M	2.21	20.05	M	1.69	15.33	S	1.37	12.43	S	—	—	—	—	—	—	—	—	—
8. *Mac. kikungshana*	5.64	23.64	M	5.18	21.71	M	4.61	19.32	S	3.89	16.31	S	2.78	11.65	S	1.75	7.33	VS	—	—	—	—	—	—
9. *M. pseudoartemisiae*	4.80	24.69	M	4.61	23.71	M	3.84	19.75	S	3.65	18.77	S	2.54	13.06	S	—	—	—	—	—	—	—	—	—
10. *Metopol. ignotum*	5.76	19.93	S	4.75	16.44	S	4.32	14.95	S	3.84	13.29	S	3.74	12.94	S	3.36	11.63	S	3.12	10.79	S	—	—	—
11. *Met. sonchifoliae*	7.80	32.01	L	6.58	27.01	M	4.37	17.93	S	3.07	12.60	S	2.54	10.42	S	—	—	—	—	—	—	—	—	—
12. *N. (K.) rostrata*	3.16	25.81	M	2.77	22.63	M	2.20	17.93	S	1.92	15.68	S	1.14	9.31	VS	1.04	8.57	VS	—	—	—	—	—	—
13. *P. (D.) cannabis*	3.45	26.31	M	2.68	20.44	M	2.46	18.76	S	1.72	13.11	S	1.53	11.67	S	1.27	9.68	VS	—	—	—	—	—	—
14. *Ur. fuscaudatus*	3.02	27.55	M	2.47	22.53	M	2.18	19.89	S	1.39	12.68	S	1.02	9.30	VS	0.88	8.02	VS	—	—	—	—	—	—
15. *U. longisetosus*	6.03	27.40	M	5.46	24.81	M	4.67	21.22	M	3.62	16.45	S	2.22	10.09	S	—	—	—	—	—	—	—	—	—

L = long; M = Medium; S = Short; VS = Very Short.

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BOTH *X* AND *Y* CHROMOSOME POLYMORPHISMS IN TWO SPECIES OF *LYGAEUS* IN A NATURAL POPULATION (LYGAEIDAE, HETEROPTERA)

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Males of lygaeid bugs, *Lygaeus hospes* and *L. pandurus* possess normally $2n = 14$ $(12A + XY)$ chromosomes showing the orthodox post-reductional meiosis. However, in the natural population in and around Kalyani, West Bengal both the species appeared sex chromosomally polymorphic each having two forms of *X* designated as *X* (original) and X_1 (transformed) and three forms of *Y* designated as *Y* (original), Y_1 (transformed) and Y_2 (fusion product of small part of *X* and *Y*). This was revealed from both morphological and metrical studies of chromosomes of different individuals. The observations made by us in *L. hospes* were reported earlier. The data have been extended and in the present paper (i) the frequency-distribution of 12 out of 18 expected sex chromosomal polymorphs in 230 males of *L. hospes* originated due to random mating for the presence of two forms of *X* and three forms of *Y* and (ii) the detection of the same *XY* and *XYY* types of chromosomal polymorphisms for the occurrence of two forms of *X* and three forms of *Y* in the other species, *L. pandurus* of the same locality have been reported.

(Key words: *X* and *Y* polymorphic, *Lygaeus pandurus; Lygaeus hospes,* Heteroptera)

INTRODUCTION

In about 1240 species of Heteroptera so far cytologically investigated, 151 odd species were reported to deviate from simple *XO* or *XY* to a variety of multiple sex chromosome mechanism having different number, size, form and behaviour in the heterogametic male sex (MANNA, 1982). On the other hand though the occurrence of an extra *Y* in some male individuals of *L. equestris*, *Rhyparochromus chiraga* etc. under Lygaeidae (PFALER-COLLANDER, 1941), and 1 to 5 *Y*s in some species of *Acanthocephala* (as *Metapodius*, WILSON, 1907, 1909) under Coreidae (the family has characteristically the absence of the *Y* – MANNA, 1951, 1956) were recorded, it was also reported by us (BARIK *et al.*, 1981) that in *L. hospes* the sex chromosomal polymorphism exists not only due to the presence of an extra *Y* (*XYY*) in some male individuals but also due to the occurrence of two forms of *X* and three forms of *Y* by the structural alteration of the original *X* and *Y*. The implication of both structural and numerical changes leading to the sex chromosomal polymorphisms in *L. hospes* was stressed but no frequency study of the different sex chromosomal polymorphic types was made. Further, strangely enough, in the same population at Kalyani, the other

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congeneric species, *L pandurus* also showed the same type of chromosomal polymorphism in the *X* and *Y* like that of *L. hospes* (BARIK *et al.*, 1981). Therefore, in the present paper (i) the frequency-distribution of males with different sex chromosome constitution in *L. hospes* and (ii) the detection of two forms of *X* and three forms of *Y* in *L. pandurus* in the same population at Kalyani have been discussed.

MATERIALS AND METHODS

230 males of *Lygaeus hospes* (F) and 80 males of *L. pandurus* (Scop.) (Lygaeini, Lygaeinae, Lygaeidae, Heteroptera) constituted the materials for the study. Both the species were collected from the same host plants, *Calotropis procera* and *C. gygantia* in and around Kalyani, West Bengal from April to September. *L. hospes* were more abundant and the method for cytological preparation of their testes and the detection of the sex chromosome polymorphs were reported elsewhere (BARIK *et al.*, 1981) while the frequency of individuals with different sex chromosome constitutions has been presented in this paper. On the other hand, testes of each of the 80 males of *L. pandurus* were fixed separately in acetic-alcohol (1:3) for a while and squashed between slide smeared with Meyer's albumin and cover-glass. After the removal of the cover-glass each slide was stained in iron-alum haematoxylin, sometime in Feulgen solution, dehydrated through grades of alcohol with two changes in absolute alcohol, cleared in xylol and finally mounted in Canada balsam.

The metrical data of chromosomes of metaphase I were scored from 10 randomly selected plates and the average was determined for each chromosome and the relative percentage volume was calculated following the method of MANNA (1951).

OBSERVATIONS

(i) *The Frequency-distribution of males with different types of sex chrymosome constitution in L. hospes:* It was reported earlier that in the natural population at Kalyani males of *L. hospes* were found to have two forms of *X* and three forms of *Y* (BARIK *et al.*, 1981). Metrical data of chromosomes of males with various *XY* and that of individuals with various *XYY* chromosomes yielded relative percentage volumes as $X = 7.51$ (original), $X_1 = 6.96$ (transformed, after removal of a small segment of the original *X*) and $Y = 1.95$ (original), $Y_1 = 1.65$ (broken major part of the original) *Y* and $Y_2 = 1.29$ (formed by fusion of small broken part of the original *X* and *Y*) (Table 1). The origin of the two forms of *X* and three forms of *Y* floating in the population was envisaged to be due to the unequal breaks in the original *X* and *Y* leading to the formation of X_1 with major broken part and the small fragment of original *X* fused to the small fragment

TABLE 1 The relative percentage volume of chromosomes in metaphase I in sex chromosomally polymorphic males of *L. hospes* and *L. pandurus* studided from Kalyani population.

Sex chromosome type	Autosome number						Sex chromosomes				
	I	II	III	IV	V	VI	X	X_1	Y	Y_1	Y_2
A. Lygaeus hospes											
Simple	19.04	17.54	15.64	14.01	12.91	11.39	7.51		1.95		
Multiple	19.27	17.62	15.98	14.01	12.96	11.75		6.96		1.65	1.29
B. *Lygaeus pandurus*											
Simple	17.20	17.02	15.68	13.00	12.27	11.29	9.40		4.12		
Multiple	18.10	16.38	14.90	14.22	11.73	11.38		7.58		3.10	2.50

of the original Y to form the Y_2 while the major broken part of the original Y transformed into Y_1 in *L. hospes* (BARIK *et al.*, 1981). However, the negligiable size differences between X and and X_1 between Y, Y_1 and Y_2 together with the variation in sizes from plate to plate in the same individual made the accurate determination of the sex chromosome constitution of 230 male individuals greately difficult. Therefore an arbitrary range of variation was set to evaluate the form of X or Y from their average volume. Any how, assuming random mating of male producing gametes with X or X_1 or Y, or Y_1 or Y_2 or any two forms of Y, sex chromosomally 18 different types were expected but in the present data only 12 types were encountered (Table 2). Possibly this was due to the very low frequency of occurrence of the absent types or else due to the difficulty of their accurate identification. In spite of these limit ations due to the inherent nature of the sex chromosomes, the frequency of males with different sex chromosome constitution was determined with a view to finding out at least broadly the trend of distribution and the influencing factor if any (Table 2).

The data (Table 2) would show that the frequency of about 74% of X (original) was approximately 3 times higher than that of about 26% in X_1. Similarly the frequency of original Y was approximately 53%, that of Y_1 29% and that of Y_2 18% indicating thereby that individuals with two forms of X and three forms of Y were present in the population in uneven manner. The original X and the Y were having posibly the selective advantage. Further, the data would show that out of the 18 expected types of sex chromosome combinations, 12 were detected (Table 2). The reason for the absence of 6 types was not known if it was due to their very low frequency of occurrence or else the combination was lethal and so on but we refrained from making any specific specularation as there was difficulty even in the accurate determination of all types for incipient differences between the two forms of X or three forms of Y. Moreover the sample number of 230 individuals appeared not very adequate because a number of observed types occurred as 1 or 2 (Table 2). The frequency of individuals with different forms of multiple XYY chromosomes was very low and out of expected types only 6 types were encountered and their total number was 11 (Table 2). Therefore, if these 11 individuals with

TABLE 2. Frequency distribution of males of *L. hospes* with different sex chromosome constitution in 230 individuals studied from Kalyani population.

A. *Original X with different forms of Y*

Type	XY	XY_1	XY_2	XYY	XY_1Y_1	XY_2Y_2	XYY_1	XYY_2	XY_1Y_2	Total
Frequency	95	46	20	4	1	1	2	0	1	170

B. *Transformed X_1 with different forms of Y*

Type	X_1Y	X_1Y_1	X_1Y_2	X_1YY	$X_1Y_1Y_1$	XY_2Y_2	X_1YY_1	X_1YY_2	$X_1Y_1Y_2$	
Frequency	21	17	20	0	0	0	0	0	2	60

TABLE 3. Frequency-distribution of observed and expected number of males of *L. hospes* with different combinations of XY elements in 219 individuals.

Type	XY	XY_1	XY_2	X_1Y	X_1Y_1	X_1Y_2	Total	Remark
Observed	95	46	20	21	17	20	219	X^2 value = 14.54
Expected	85	46	29	31	17	11	219	Significance $P < 0.00$

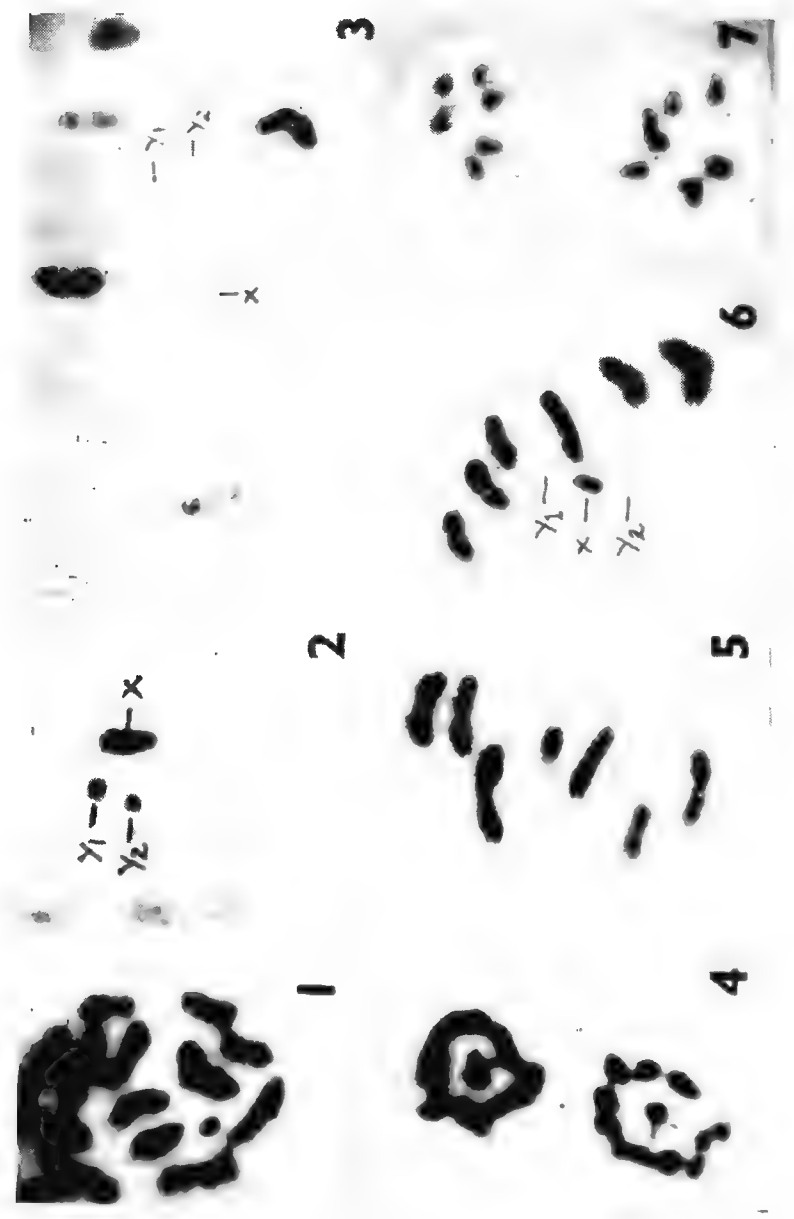
XYY-types sex chromosomes were set aside, the observed and the expected number of individuals with two forms of *X* and three forms of *Y* in a total of 219 individuals with only simple *X* and *Y* chromosomal elements was compared (Table 3), it would show that the difference between the observed and expected number of males with different forms of *XY* combinations was statistically significant ($P < 0.001$).

Therefore, it seemed that some sex chromosomal combination of *XY* elements was enjoying selective advantage but that would need further study for verification. For the present it might be pointed out from the data (Tables 1–3) that in spite of some inherent difficulties in accurate observations, studies of the sex chromosomal polymorphisms for two forms of *X* and 3 forms of *Y* found in *L. hospes* at Kalyani population were indicative of the evolution of sex chromosomal mechanism in action. In Heteroptera though the origin of multiple sex chromosome mechanism was considered to be mainly due to the fragmentation and fusion of sex chromosomes (WHITE,1973), there was no evidence in support of the same studied from some polymorphic species. On the other hand the study of the sex chromosomal polymorphisms in *L. hospes* at Kalyani population revealed that both structural alterations and non-disjunction played the role in the evolution of sex chromosome mechanisms in *L. hospes* as well as in *L. pandurus (vide infra)*, and such form of sex chromosomal polymorphisms was not reported before.

(ii) The detection of two forms of X and three forms of Y in L. pandurus: The cytological preparations of the testes of 80 male individuals of *L. pandurus* collected from Kalyani population revealed surprisingly the same type of sex chromosome polymorphisms for having two forms of *X* and three forms of *Y* and 6 individuals were with *XYY* type sex chromosome mechanism, the detection of all of them was made by morphological and metrical methods (Table 1) as done for *L. hospes* (BARIK *et al.*, 1981). On the other hand the study on the behaviour of chromosomes during meiosis in male *L. hospes* and *L. pandurus* carried out by MANNA (1951) in specimens collected from a different place near Calcutta (difference between Kalyani and Calcutta about 50 km) revealed all of them to be monomorphic type *XY* males having characteristic orthodox meiotic chromosome behaviour like most other species of Lygaeini (MANNA, 1956, 1962). The behaviour of chromosomes during meiosis in *L. pandurus* collected at Kalyani in males with simple *XY* elements be it *X* or X_1 and *Y*, Y_1 or Y_2 (*XYY* individuals excluded) was the same as that of Calcutta population. Therefore, the structural differences in the *X* or *Y*

elements did not involve any difference in the meiotic behaviour because in Heteroptera no pairing and chiasma formation take place in first meiotic division and for this reason any structural heterogeneity if exists in some population would generally not be revealed unless the investigator was struck by some difference as were the cases of *L. hospes* or *L. pandurus*. Anyhow the spermatogonial metaphases in different forms of *XY* males of Kalyani population contained 13 medium to small including the *X* and one minute *Y* chromosome making $2n = 14$ ($12A + XY$). The *Y* was distinctly demarcable by its size but this was not applicable for the *X* as there were autosomes close to its size. During first spermatocyte the *X* and *Y* elements remained separate upto anaphase I and at metaphase II they formed the pseudo-bivalent to undergo reduction division at anaphase II showing orthodox behaviour. The variable structure of the *X* and *Y* elements could only be revealed when it was critically examined (Table 1) and an examination of the metrical data of chromosomes of two species of *Lygaeus* would reveal that though there was no difference in the meiotic behaviour, structurally they were different. As for sex chromosomes they were more voluminous in *L. pandurus* than that of *L. hospes* eg., 9.40% against 7.51% in *X*. 7.58% against 6.96% in X_1, 4.12% against 1.95% in *Y*, 3.10% against 1.65% in Y_1 and 2.50% against 1.29% in Y_2 respectively (Table 1). In fact the discovery of the 6 individuals with an extra *Y* element in addition to the normal *XY* made us to examine critically the size of the *X* and *Y* elements in different individuals. Individuals with multiple *XYY* chromosomes had $2n=15$ chromosomes in spermatogonial metaphase (Fig. 1) consisting of 13 medium to small including either the *X* or X_1 and two distinguishably very small elements representing *YY*, YY_1, YY_2, Y_1 Y_1, Y_1 Y_2 or Y_2 Y_2 but all the combinations were not encountered for multiple sex chromosomes. The two forms of *X* and three forms of *Y* among different stages of spermatogenesis could more conveniently be identified at the first spermatocyte diffuse stage (Fig. 2) when the autosomes were negligibly stained while the sex chromosomes were deeply stained and at metaphase II (Figs. 5, 6) when the *X* and two *Y* elements formed the pseudotrivalent structure and that provided their closer comparison. The three sex elements could also be identified at metaphase I when they showed independent univalent structure all lying within the ring surrounded by 6 larger autosomal bivalents (Fig. 3). The typical arrangement of chromosomes at metaphase I could even persist in anaphase I (Fig. 4). The arrangement of the sex chromosomes at metaphase II was typical which would occupy the central position within the ring formed by 6 autosomes. The three sex elements forming pseudo trivalent might arrange in different ways as linear (Fig. 5), triradiated, two *Y*s associated with the two end of the *X* (Fig. 6). They oriented more or less in the same way as found in *L. hospes*. The anaphase II was reductional for the sex chromosomes showing the *X* element moved to one pole and the two *Y* elements to the other (Fig. 7).

That 80 males of *L. pandurus* of Kalyani population had two forms of *X* as *X* (original), X_1 (transformed) and three forms of *Y* as *Y* (original), Y_1 (transformed) and Y_2 (by fusion of small



Figures 1—5 are of meiotic stages in males with multiple sex chromosomes in *L. pandurus*. Fig. 1—Spermatogonial metaphase; Fig. 2—Diffuse stage in first spermatocyte; Fig. 3—Metaphase; Fig. 4—Anaphase I; Figs. 5 & 6—Metaphase II; Fig. 7—Anaphase II.

broken part of original *X* and *Y*) were ascertained from morphological appearance supported with metrical data. The origin of these sex elements very likely took place by the same way of breakage and fusion of the unequal fragmented parts of the original *X* and *Y* as speculated for the origin of the same forms of chromosomes in *L. hospes*. In *L. pandurus* the relative volume of the original *X* was 9.40 of which less than 2% were deleted to give rise to the X_1 measuring about 7.58% (Table 1). The original *Y* measuring 4.12% was also broken to form in one hand the Y_1 measuring 3.10% and on the other the smaller part of the original *Y* joined with the smaller part of the broken *X* to give rise to the Y_2 having the volume of 2.50% (Table 1). While the origin of the two forms of *X* and 3 forms of *Y* was envisaged above, the *Y*s also underwent nondisjunction to have multiple sex chromosomes with an extra *Y*. The frequency of different sex chromosomal polymorphs of *L. pandurus* was not attempted to determine at present because the sample was small while 18 polymorphic forms were expected like *L. hospes*. Any how, the origin of the so called neo-*X* and *Y* and the multiple sex chromosome in *L. hospes* and *L. pandurus* was the same and unique in Heteropteran sex chromosomal evolutionary mechanism.

The inter-individual variation in the size of the *Y* chromosome of man with some genetical implications has been reported (HAMMERTON, 1971) while the variation in the size of the *Y* in two species of *Lygaeus* would have possibly no genetical significance because the *Y* chromosome is said to be genetically inert in insect. However, we are really ignorant about the true significance.

The sex chromosomal polymorphisms in two species of *Lygaeus* were of some-what new because both structural and numerical changes in the sex chromosomes were involved which was not known in any other species of Heteroptera. However, some species like *L. equestris* was reported to have *XYY* and *XY* males. One might wonder if the said species have the same type of chromosome polymorphism like the two species of *Lygaeus* under present study. They might have escaped attention of PFALER-COLLANDER (1941), because the type of sex chromosome polymorphisms reported here was not clear at the beginning. Any how the study of the population dynamics in two species of *Lygaeus* in successive years might throw more light on the trend of the sex chromosomal evolution with adaptive significance. In fact the sex chromosomes in evolution showed more dynamism than auto somes in Heteroptera (MANNA, 1984) and the two species of *Lygaeus* partly subscribed to that.

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SEX DETERMINATION AT PUPAL STAGE IN THE RED HAIRY CATERPILLAR, *AMSACTA MOOREI* BUTLER

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A practical method for sexing the pupae of *Amsacta moorei* Butler (Lepidoptera : Arctiidae) has been worked out. Among the various parameters examined, location of genital pore, and the ratio of distances between genital and anal pores, have been found to be reliable criteria for pupal sexing and is easily practised. Possibility of visually sexing the moths is indicated.

(Key words: pupal and adult sexing, red hairy caterpillar, *Amsacta moorei* Butler)

The red hairy caterpillar, *Amsacta moorei* Butler (Lepidoptera : Arctiidae), is a serious, polyphagous pest in arid and semi-arid regions of Rajasthan, India. While investigating the effect of chitin inhibitor on adult sterility, it was felt necessary to develop an accurate and quick method for sexing the insects at pupal stage. Earlier, pupal-sexing had been attempted in a few insect species wherein, the colour, size, weight, behaviour, elevation of antennae, number of abdominal segments, genital and anal pores, and the ratio of the distance between these pores have been taken as criteria for pupal-sexing (Solomon, 1962; Peterson, 1967; Narayanan *et al.*, 1977; Navrajan Paul *et al.*, 1979).

In the present investigation, the pupae of *A. moorei* from uniparental culture, reared on Moong (*Phaseolus aureus)*, were screened for sexual identity. In all, 175 pupae were examined. The pupae of both the sexes were alike in colour and no abdominal movement was observed in either sex. (Solomon, 1962) had reported that in *Ennomos subsignarius*, the male pupae were normally darker and showed more frequent abdominal wriggling. There was a marked difference in size, and female pupae weighed almost double that of the males (Table 1) in *A. moorei*. In general, males were much smaller than the females and this criterion gave a fair degree of success in sexing laboratory reared insects. However, field collected pupae sometimes gave a different picture as the attributes for size and weight, like type of food, climatic condition and parasitism were quite variable in nature.

The most reliable characters for determining the sexes in the pupae are the location of genital pore, and the ratio of distance between genital and anal pores. In both the sexes, the genital and anal pores are mid-ventral in position. In the male pupae, the genital pore is borne on ninth abdominal segment and is usually provided with crescent shaped depression on either side (Fig. 1).

TABLE 1. Morphometric variations in male and female pupae of *Amsacta moorei*.

Characters *	Pupae	
	Male	Female
Distance between anal genital pores	0.309 ± 0.036	1.168 ± 0.056
Length of genital pore	0.252 ± 0.036	0.227 ± 0.025
Length of anal pore	0.543 ± 0.036	0.584 ± 0.025
Abdominal length (post wing pads)	6.112 ± 0.311	6.462 ± 0.216
Abdominal width	5.887 ± 0.213	6.425 ± 0.103
Pupal weight	0.267 ± 0.051	0.461 ± 0.025

* Measurement in mm ± SE (Mean of minimum 10 observations)

In a few pupae, this depression has been observed all around, excepting the distal end of the genital pore, and the space between the depression and genital pore is convex. In the female pupa the genital pore is located on eighth abdominal segment (immediately below the seventh abdominal segment); the depression and the convexity all around it, are wanting The anal pore is present on the tenth abdominal segment in both the sexes. The ratio of distances between genital and anal pores in male and female pepae is about 1:3.75.

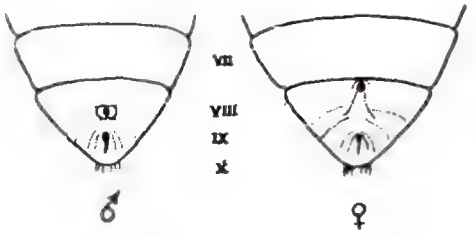

Fig. 1. Ventral view of 7th to 10th abdominal segments of the pupae of *A. moorei*.

These investigations show that several parameters may be used to distinguish the sexes of *A. moorei* pupae. But the location of genital pore, and the ratio of distance between the genital and anal pores seem to be the reliable criteria for sexing the pupae. The location of pores can be easily observed with the help of a hand lens, though, for estimating the distances between the pores, microscopy is needed.

Adult sexing can be easily accomplished visually by the presence of six dusky black horizontal stripes and a small triangular spot on the last abdominal segment in males. In females, these stripes are better marked and the triangular spot is wanting. The gonosomite has a ventrally located triangular depression, just prior to genital pore, which is more pronounced in males. The genital pore is quite clearly visible in females, while in males, it is partially covered with scales. The antennal pectination is more developed in males as compared to females; this can only be observed microscopically.

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EFFECT OF SOME NUTRITIONAL MANIPULATIONS ON GLUCOSE AND TREHALOSE LEVELS IN LARVAL HAEMOMOLYMPH AND FAT BODY OF *CORCYRA CEPHALONICA* (STAINTON) (LEPIDOPTERA : PYRALIDAE)

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Results of experimental investigations into some of the nutritional changes in the diet affecting glucose and trehalose levels in the haemolymph and fat body of 25-day old fourth instar larva of the rice moth, *Corcyra cephalonica* are presented and discussed.

(Key words: glucose - trehalose levels, haemolymph, fat body, *Corcyra cephalonica* larva, nutritional manipulations)

BHATT & KRISHNA (1984) reported the changes that occurred in the free amino acids and protein content of the haemolymph and fat body of the larva of the rice moth, *Corcyra cephalonica* (Stainton) in relation to certain changes in the diet. The present report deals with changes in the composition of sugars in these two larval tissues following similar experimental manipulations in the diet.

All procedural details in this investigation pertaining to (a) rearing and pre-experimental conditioning of larvae, (b) formulations of dietary regimens and, (c) collection and preparation of ethanolic homogenates of haemolymph and fat body from caterpillars fed on various diets for qualitative assay of sugars in these two larval tissues by paper partition chromatography (BHATT & KRISHNA, 1982) were the same as described earlier (BHATT & KRISHNA, 1984). The sugars tested for were: cellobiose, fructose, galactose, glucose, lactose, maltose, melibiose, raffinose, sucrose and trehalose. Visualization of all the sugars except trehalose on developed chromatograms was made possible by treating the papers with benzidine-trichloracetic acid mixture (BACON & EDELMAN, 1951; BHATT & KRISHNA, 1982). Trehalose was, however, detected on the chromatogram with ammoniacal silver nitrate solution (TREVELYAN *et al.*, 1950). Chromatographic analysis of each test sample was performed at least thrice.

Concentration of trehalose present in the haemolymph, expressed as mean percentage values on wet weight basis calculated from 5 separate determinations, was quantitatively assayed thus: Haemolymph of known weight was first homogenized in 0.5 ml of 80% aqueous ethanol and four fractions of 0.1 ml each were drawn out from this mixture

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after centrifugation and were subjected to paper partition chromatography (BHATT & KRISHNA, 1982) subsequent to plotting them at separate loci on the same paper. Sectors of the developed chromatogram containing two of these fractions and the standards were cut out after air drying the filter paper sheet and then visualized. Locations of trehalose, present in the remaining two fractions of the ethanolic extract of haemolymph, on the unvisualized sector of the chromatogram were marked out with reference to their visualized counterparts. Trehalose from each of these fractions was separately eluted in distilled water and the final volume of the eluate was maintained at 2 ml. The amount of sugar present in each eluate was measured colorimetrically by treating it with anthrone reagent (MORRIS, 1948).

Haemolymph and fat body of the larva of *C. cephalonica* showed the presence of only glucose and/or trehalose (Table 1). Although the remaining 8 sugars checked for were never detected from both these tissues of the caterpillars at any test situation (which obviously imply their total absence from the carbohydrate profiles of the haemolymph and fat body of this insect), glucose failed to appear in the larval blood or in its fat body only in individuals nourished all through on normal jowar reinforced with yeast. This may possibly be due to instant conversion of glucose to glycogen in the fat body following its quick arrival from the blood. Interestingly, trehalose was not detected in the fat body under any condition examined here. Apparently, all or most of this non-reducing disaccharide, synthesized primarily in the fat body, swiftly got transported to the haemolymph leaving no trace or only an amount below detectable limit of this sugar in the former tissue.

The amount of trehalose determined in the blood of these caterpillars deriving their nourishment partly from

TABLE 1. Sugars in the haemolymph and fat body of the larva of *C. cephalonica* fed all through on normal jowar supplemented with yeast or from the 16th day of its life on differently extracted jowar enriched with yeast.

Diet (jowar plus yeast)	Haemolymph										Fat body									
	c	f	g	ga	l	m	me	r	s	t	c	f	g	ga	l	m	me	r	s	t
Normal	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–
Water extracted	–	–	+	–	–	–	–	–	–	+	–	–	+	–	–	–	–	–	–	–
Ether-extracted	–	–	+	–	–	–	–	–	–	+	–	–	+	–	–	–	–	–	–	–
Chloroform-extracted	–	–	+	–	–	–	–	–	–	+	–	–	+	–	–	–	–	–	–	–
Ethanol extracted	–	–	+	–	–	–	–	–	–	+	–	–	+	–	–	–	–	–	–	–

c = cellobiose; f = fructose; g = glucose; ga = galactose; l = lactose; m = maltose; me = melibiose; r = raffinose; S = sucrose; t = trehalose. + indicates present; – iddicates absent.

normal jowar mixed with yeast and partly from one of the 4 types of extracted jowar reinforced with yeast was always relatively higher than that recorded in the haemolymph of those fed all through only on yeast-added normal jowar and it reached a maximum when the diet consisted of jowar extracted with 100% ethanol (Fig. 1). Perhaps such midway interference in the nutritional ecology of the developing rice moth larvae stimulated the neuroendocrine system to produce and release appropriate hormone (trehalagon) (STEELE, 1980) leading to such hypertrehalosemic condition.

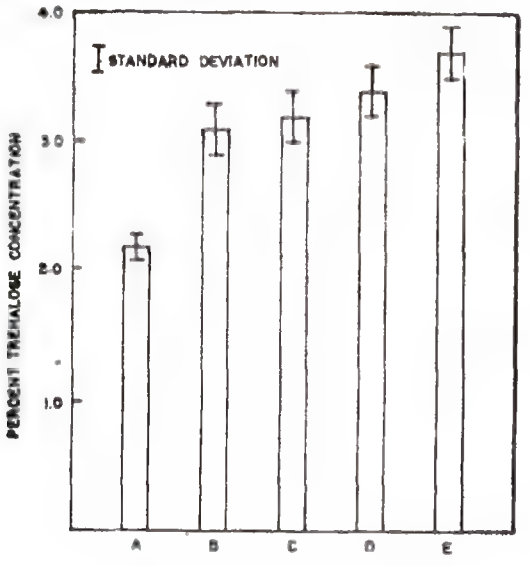

Fig. 1. Histogrammic representation of trehalose concentration in the haemolymph of the larva of *C. cephalonica* fed all through on normal jowar supplemented with yeast (A) or from the 16th day of its life on jowar extracted with water (B), ether (C), chloroform (D) or 100% ethanol (E) and then enriched with yeast.

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STUDIES ON MIDGUT PROTEASE ACTIVITY DURING FIFTH INSTAR DEVELOPMENT OF THE SILKWORM BOMBYX MORI L.

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The midgut protease activity of fifth instar larva of bivoltine and multivoltine races of *Bombyx mori* and their hybrids was measured. Activity pattern of the enzyme was different in both the pure races. The level of protease activity in bivoltine was about 2.5 times higher than that of multivoltine. F_1 hybrids showed a change in the activity pattern which was maintained during F_2 generation. Excepting a few stages of fifth instar development, there was no significant difference in protease activity between males and females of both the pure races and the hybrids. The results are discussed in relation to the differential silk output by different silkworm varieties.

(Key words: Bombyx mori, bivoltine, multivoltine, hybrid, larval protease, commercial characters)

INTRODUCTION

A strong protease activity has been demonstrated in the digestive fluid of the silkworm *Bombyx mori* (SHINODA, 1930; HORIE *et al.*, 1963; EGUCHI & YOSHITAKE, 1967; HAMANO & MUKAIYAMA, 1970; EGUCHI & IWAMOTO, 1976; SASAKI & SUZUKI, 1982). The presence of proteolytic activity in the midgut lumen, epithelia and peritrophic membrane has been shown in *Bombyx mori* (EGUCHI *et al.*, 1982; EGUCHI & ARAI, 1983). EGUCHI & IWAMOTO (1982) have shown that the midgut protease in silkworms is a trypsin-like enzyme as in most of the insects (DAY & WATERHOUSE, 1953; GILMOUR, 1961; HOUSE, 1974; WARD, 1975; KUNZ, 1978a, b). However, very little is known about the changes in total protease activity during fifth instar development which might reflect the physiological status of the worm in different voltinism.

Utilization of exogenous proteins is an important factor for growth and development of the larva in insects (CHEN, 1978). ITO (1978) has reported that about 60% of the total nitrogen content of the mulberry leaf is used for silk synthesis. Thus, midgut protease might be playing an important role in influencing the growth as well as silk production in the fifth instar larva of silkworms. The present communication deals with a comparative study on the changes in total midgut protease activity during fifth instar development of two pure races and their hybrids. Further, a few important commercial characters are analysed to correlate with the changes in midgut protease activity in different silkworm varieties.

MATERIALS AND METHODS

Animal: Bivoltine ($NB_{1\,8}$), multivoltine (*Pure Mysore*) silkworm races and their hybrids

(*Mys* ♀ × NB_{18} ♂) were reared under standard laboratory conditions at 25—28°C and a relative humidity of 70—90% on mulberry leaves (*M5* variety) fifth instar larvae were used from fourth moult upto spinning at 24 h intervals. The midgut was excised along with its contents after freezing the animals for about 12 h at —20°C to avoid any loss of protease activity as most of it is detected in the digestive juice. A 10% (W/V) homogenate of the tissue was prepared in ice-cold borate buffer, pH 11.0, centrifuged in an IEC refrigerated centrifuge at 3000 RPM for 15 minutes and the supernatant was used as the enzyme source. Two to three larvae were taken for independent determination and the mean value of four to five determinations with standard deviation is presented in graphs.

Enzyme assay: Protease activity was measured according to the procedure of EGUCHI & IWAMOTO (1982) with a slight modification that the pH was 11.0. 0.5ml of 1% casein and 2ml of 0.1M borate buffer were incubated with 0.5ml enzyme solution for 30 min at 30°C. The reaction was stopped by adding 2ml of 10% TCA and centrifuged. The concentration of digested protein in the supernatant was determined colorimetrically with Beckman DU2 spectrophotometer using Folin's reagent at 660 nm. Protein concentration was determined according to the method of Lowry et al. (1951). The activity of the enzyme was expressed as μ moles of tyrosine formed per minute per mg of protein.

Analysis of cocoon characters: Four to five lots of 10 cocoons each, were taken after harvesting from bivoltine, multivoltine and the hybrid silkworm varieties. Important cocoon characters like cocoon weight, shell weight percentage, Floss weight percentage and filament length were analysed. Shell weight was given by the ratio between the cocoon shell and the whole cocoon, while the floss weight was the ratio between total floss and the whole cocoon. The mean value of the lots with standard deviation is presented in the Table.

RESULTS

Fig. 1 shows the protease activity in pure races. In case of bivoltine, the midgut protease activity increased significantly ($P < 0.001$) from 24 h to reach the peak at 72 hr in males and females respectively and then decreased gradually upto the spinning stage. But in case of multivoltine, the enzyme activity increased slowly from fourth moult to reach the peak at 120 h and decreased gradually thereafter. Excepting one stage (72 h) of bivoltine, there was no significant

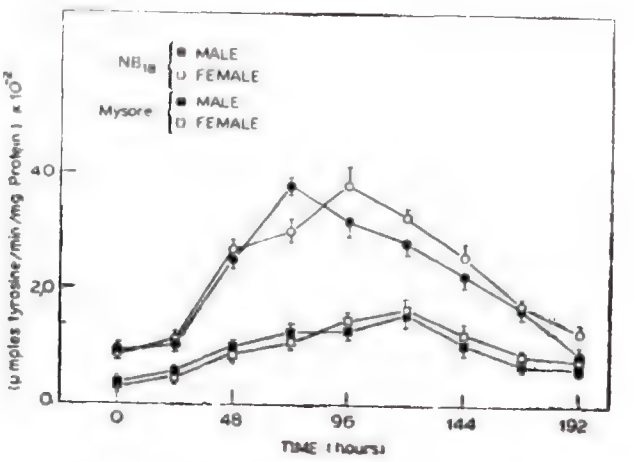

Fig. 1 Changes in midgut protease activity during fifth instar development of bivoltine and multivoltine.

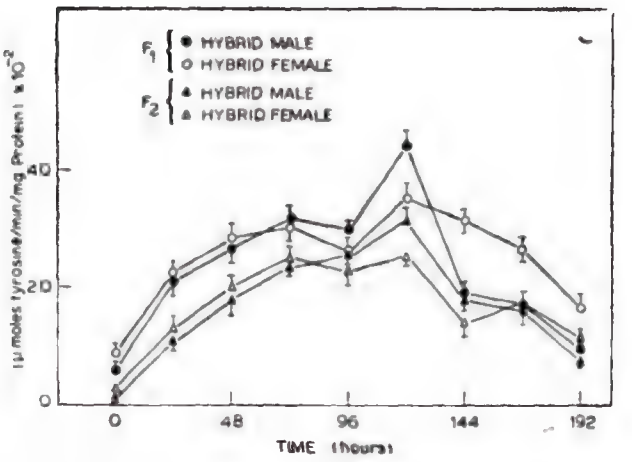

Fig. 2. Changes in midgut protease activity during fifth instar development of the hybrid.

difference in protease activity between males and females. However, the enzyme activity in bivoltine was high compared to that of multivoltine.

As thown in Fig. 2, the protease activity in the hybrids reached peak at 120 h and decreased significantly ($P<0.001$) thereafter. A minor peak at 72 h was observed in both the sexes of F_1 hybrid and F_2 females. Males and females of the hybrids showed a significant difference ($P<0.001$) in the enzyme activity at peak levels. However, protease activity was significantly high ($P<0.001$) in F_1 hybrids compared to F_2 hybrids during most of the stages of fifth instar.

Table 1 shows a few commercial characters of the silkworm varieties. All the characters analysed were better in bivoltine than multivoltine while the F_1 hybrid showed an improvement of these characters over the multivoltine parent. But F_2 hybrids showed a marked deterioration of these characters as compared to F_1 hybrids.

DISCUSSION

Digestive enzymes play a major role in the body of insects by converting complex food materials into micromole cules necessary to provide energy and metabolites for growth, development and other vital functions (WATERHOUSE, 1957; HOUSE, 1965; WIGGLESWORTH, 1972a, b). Present results indicate that there is considerable variation in midgut protease activity in different silkworm varieties. High activity of midgut protease in bivoltine might account for a greater utilization of exogenous proteins resulting in the production of more silk. Multivoltine, on the other hand, shows a low midgut protease activity concomitant with lowered silk output. Peak activity of protease at different times of fifth instar shows the difference in the rate of physiological events occurring in the worm.

TABLE 1. Important cocoon characters of bivoltine, multivoltine and the hybrid varieties.

SW variety	A. V. Cocoon wt. (in g)		Shell wt. percentage		Floss wt. percentage		A. V. filament length (in m)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
$NB_{1\,8}$ (Bivoltine)	1.28 ± 0.06		14.35 ± 0.80		0.79 ± 0.80		780 ± 55	
Pure Mysore (Multivoltine)	0.88 ± 0.04		9.59 ± 1.02		2.25 ± 0.18		350 ± 25	
F_1 hybrid	1.08 ± 0.06		12.02 ± 1.05		1.38 ± 0 09		620 ± 35	
F_2 hybrid	0.90 ± 0.04		10.00 ± 0.88		1.76 ± 0.20		450 ± 45	

F_1 hybrids show an increase in protease activity over multivoltine parent resulting in an improvement in silk output. A slight sexual difference and the occurrence of a minor peak in protease activity in the hybrids might be a parental influence. In general, the hybrid characters deteriorate through further inbreeding (GOPALAKRISHNAN *et al.*, 1974). Similarly the increased protease activity and the improved cocoon characters in F_1 hybrid decrease through F_2 generation. This decrease, however, may be due to segregation of characters and/or several factors affecting the silkworm rearing and the physiological status of the worm. But a low midgut protease activity in multivoltine and F_2 hybrid shows clearly that the utilization of exogenous protein decrease considerably resulting in a poor silk yield. Thus it can be surmised that midgut protease activity possibly influences to a great extent the silk output in different silkworm varieties.

Acknowledgement—The author acknowledges the World Bank for financial assistance and the Co-ordinator, R & D Programme in Sericulture, Bangalore University for providing facilities.

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SPATIAL DISTRIBUTION OF BRINJAL SHOOT- AND FRUIT BORER, *LEUCINODES ORBONALIS* GUEN ON BRINJAL

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Spatial pattern of brinjal shoot- and fruit borer *(Leucinodes orbonalis)* has been studied for four generations on brinjal. The mean and variance approximated toward each other in all the generations. The mean crowding and Lloyd index indicated random dispersion of brinjal shoot- and fruit borer population which may be attributed to scattered egg laying pattern of adult population. The data showed high degree of agreement between observed and expected frequencies of Poisson distribution.

(Key words: spatial distribution, brinjal shoot- and fruit borer, *Leucinodes orbonalis)*

INTRODUCTION

The brinjal shoot- and fruit borer is widely distributed all over India, and is associated with a number of host plants like potato, brinjal, *Solanum xanthocarpum*, *S. indicum*, *S. nigrum*, bitter gourd and pea pods. It is one of the most serious pests of brinjal fruits and plants.

The infestation on brinjal crop starts after a few weeks following transplantation which results in withering of leaves, fruit buds and shoots. The larva bores inside the petiole and midribs of larger leaves. The plant exhibits symptoms of droping while fruits show holes on their surface plugged with excreta. The infestation on brinjal can be as high as 70 per cent (LAL, 1964).

The knowledge of spatial pattern is fundamental to the studies on insect ecology. The spatial distribution of the natural population of insects is neither regular nor purely random. The regularity results from mutual repulsion such as might occur if the members of the population were so abundant that they compete with one another for their available space. True randomness occurs when the presence of an individual does not in any way affect that of another. Few environments are completely homogenous and population dispersion usually leads to aggregation. Aggregated population occurs when the presence of an insect on a plant increases the probability of others occurring on that plant. It results from egg laying habit of insects, gregariousness of feeding larvae etc. Aggregation or lack of it has direct bearing on dynamics of all species in the ecosystem.

The distribution most commonly used to describe insect populations are normal, Poisson, positive binomial logrithmic, discrete lognormal, Neyman

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contagious type A and negative binomial distribution (ANSCOMBE, 1949; WADLEY, 1950; EVANS, 1953; BLISS & OWEN, 1958; WATER, 1959; SUMAN et. al. 1980, 1981). First three are random distributions and the others are non-random pertaining to over-dispersed distribution. As the variance approach is mean, distribution tends toward Poisson distribution.

This paper describes the distribu;ion pattern of brinjal shoot- and fruit borer on brinjal for four generations.

MATERIALS ND METHODS

The experiment was conducted at the Experimental Research Station, Hessarghatta of the Indian Institute of Horticultural Research, Bangalore by maintaining four generations of brinjal shoot and fruit borer (*Leucinodes orbonalis*). Four crops of brinjal Var. *Pusa Purple Long)* were raised during the month of March, May, July and October, 1980 to maintain the continuity of pest population. The crops were spaced at a distance 50 cm within the row and 60 cm between the rows. No plant protection measures were applied to allow the pest population to build up under natural environments. During the flowering period, the plants were sampled randomly and were tagged for recording of data on pest population in all the generations. Samples of size 575, 546, 506 and 500 plants were maintained for first, second, third and fourth generation respectively as experimental material. During regular pickings, brinjal fruits infested from each of tagged plant were utilized for recording of pest data. The population observed in all pickings was pooled to obtain per plant borer population duing the life cycle of the pest for each generation separately.

The pest counts per plant were summarised in the form of frequency table for fitting of mathematical distribution. Frequency distributions involved are of interest; these can tell us of the tendencies of organisms concerned, and for the light they shed on proper statistical analysis. Here procedure of fitting the Poisson distribution has been explained as data was adequately fitted to it.

The density function of Poisson distribution for given number X is defined as

$$p(x) = \frac{\bar{e}^{\,x}\ \bar{x}^{\,x}}{x\,!}$$

where $\bar{x}$ is simple mean. The equality of mean and variance is an important characterstic of this distribution. Probabability of of zero counts is given by

$$p(o) = \bar{e}^{\,x}$$

and the formula for calculation of expected frequencies given by

$$p(x) = \frac{\bar{x}.\ p(x-1)}{x}$$

RESULTS AND DISCUSSION

Different statistical parameters of distribution behaviour viz. Mean density ($\bar{x}$), variance (s^2), mean crowding (x^x) LLOYD (1967) index of patchiness and variance and mean ratio are shown in Table 1. The mean density of population remained stable during the entire period of study. The variance was less than mean in second and third generations and has tendency to approach toward each other in first and fourth generation. The closeness of mean and variance in all the generations revealed that pest population has tendency toward random dispersion. The variance and mean ratio did not differ significantly from unity further indicating that pest population at different densities in all the generations followed random dispersion. The random behaviour may be attributed to scattered egg laying pattern of adults and also to minimise the feeding competition of growing larvae. Generally single or two larvae were observed per fruit.

Mean crowding and mean density did not differ significantly from each other in all the generations is an evidence of random behaviour of brinjal

TABLE 1. Statistical parameter of Poisson distribution of brinjal shoot and fruit borer (*Leucinodes orbonalis*) .

Pest population per plant	Ist generation		IInd generation		IIIrd generation		IVth generation	
	observed frequency	expected freqnency	observed frequency	expected frequency	observed frequency	expected frequency	observed frequency	expected frequency
0	101	96.71	90	92.05	83	89.77	80	79.72
1	171	172.40	162	163.88	159	155.24	149	146.38
2	154	153.66	151	145.87	145	134.22	137	134.38
3	84	91.31	85	86.56	71	77.37	79	82.24
4	43	40.69	41	38.52	33	33.45	34	37.75
5	14	14.51	13	13.72	10	11.57	11	13.86
6	5	4.31	4	5.40	4	3.33	5	4.24
7	2	1.10			1	1.05	3	1.11
8	1	0.31					2	0.32
Total	575		546		506		500	
Mean ($\bar{x}$)	1.9825		1.7802		1.7292		1.8360	
Variance (s^2)	1.8360		1.6984		1.6552		1.9970	
($S^2_{\bar{x}}$)	1.0299		0.9540		0.9572		1.0870	
Mean crowding (X^*)	1.8126		1.7343		1.6865		1.9237	
Lloyd Index	1.0168		0.9742		0.9753		1.0478	
Chi-square value	1.8455		0.4698		2.0309		4.6262	
D. F.	5		5		5		6	
Prob. of Pit	0.80–0.90		0.999		0.80–0.90		0.50–0.70	

shoot and fruit borer population. In all the generations, the mean crowding was less than two indicating that population remained stable. The ratio of mean crowding and mean density is an appropriate index to study the distribution pattern of insect population. Lloyd index (1967) values did not differ significantly from unity in all the generations indicating that the borer population has definite tendency toward random dispersion.

Three distributions. namely, binomial, Poisson and negative binomial were tried to fit the data of all the generations. The data differed significantly from expected frequencies of binomial and negative binomial distribution and are not represented in the table. As seen from Table 1, the data showed good agreement between observed and expected frequencies of Poisson distribution in all the generations. The value of chi-square as test of goodness of fit showed very low value for all the generations and revealed that brinjal shoot and fruit borer poulation has high degree of closeness with Poisson frequencies under natural conditions.

The above study revealed that brinjal shoot and fruit borer population followed random dispersion under natural condition and the data was adequately fitted to Poisson dissribution.

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THE BIOLOGY OF THE FLEA BEETLE, *ALTICA CAERULA* OLIVIER (COLEOPTERA : CHRYSOMELIDAE : ALTICINAE) A PEST ON MOUNTAINOUS WEED *RUMEX* SP.

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Research station was set up at Sanjauli (Simla (H. P.) for the study of life-history of *Altica caerula* Oliv.— a pest on *Rumex* sp.— a common weed of Himachal Pradesh, Punjab and Haryana. Mating lasts for 3—10 hours. Eggs are laid singly or in clusters of 10—21 on the ventral surface of the leaf. Incubation period of egg is 7—9 days. Larval stages comprising 3 larval instars, are completed in 16—17 days. Pupal period varies from 11—13 days. Total life-history is completed in 34—39 days. Full—grown larva crawls to the ground and pupates in the debris soil. Both larvae and adults feed voraciously on the leaf tissue. A pentatomid bug is found to predate upon the larvae of *Altica caerula* Oliv.

(Key words: Altica caerula Oliv., *Rumex* sp , pest biology)

INTRODUCTION

In July 1983, during a tour for collection in the mountainous area of Simla and Chail, a black flea beetle referable to *Altica caerula* Oliv. was found feeding voraciously on the mountainous weed *Rumex* sp. A thorough survey of literature revealed that although some accounts relating to the biology, description and keys of certain species of *Altica* Fab., have been published by KEVAN (1962), KRAL (1964—1979), EDMUNDS (1965), MOHR (1966), BARSTOW & GITTINS (1971) there exists almost no information regarding the biology and life-history of this species. Keeping this in view an attempt is made here to provide the requisite information in respect of *Altica caerula* Oliv.

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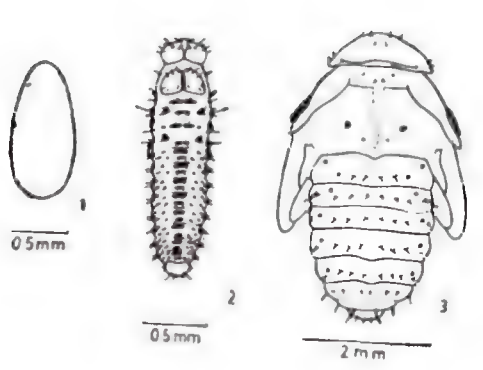
MATERIALS AND METHODS

Life-history of the flea-beetle *Altica caerula* Olivier was studied in the laboratory at a temperature 20±2°C and 60—70% RH. Beetles were collected from the host plant *Rumex* sp. and placed in 15 collection jars (one pair in each jar) covered with muslin cloth and were fed on the fresh leaves of the host plant. Eggs laid on the leaves were counted daily. Eggs were removed and kept on moist filter-paper in a petri-dish (15 cm diameter). The hatched larvae were reared separately on the leaves of *Rumex* sp. kept in petri-dishe containing wet filter-papers at the bottom. The third instar larvae were transferred to the glass vials (15×75 mm) half-filled with moist sand and wrapped in black paper for pupation. Number of larval instars, duration of each larval instar and pupal period were noted. Various morphometric measurements were done with ocular micrometer and diagrams were drawn with the help of graph eye-piece.

OBSERVATIONS

Description of life-stages:

Egg: The oval eggs measuring 1.12 ± 0.1 mm (range 1.06 mm to 1.20 mm)



× 0.50 ± 0.12 mm (0.45 mm to 0.54 mm), are yellowish in colour, turn creamish before hatching (Fig. 1).

Larvae: Tiny, newly hatched larvae, each measuring 1.23 ± 0.06 mm (1.20 mm) to 1.28 mm) × 0.43 ± 0.1 mm (0.40 mm to 0.48 mm) on an average, has creamy body with four dark spots bearing setae on the thorax on the dorsal side, and papilla around setae throughout the body on dorsal, ventral and lateral sides. The head is brownish black in colour (Fig. 2). The body soon darkens with head, legs, papillae around setae and spots on thorax becoming black. Larvae feed, grow and increase in size. Second instar larva measures 3.48 ± 0.1 mm (range 3.44 mm to 3.51 mm) × 0.81 ± 0.08 mm (range 0.78 to 0.85 mm) on an average. Last instar i.e., third instar larva measures 5.13 ± 0.09 mm (5.10 mm to 5.15 mm) × 1.21 ± 0.1 mm (1.16 mm to 1.24 mm) on an average. A fully grown third instar larva measures 7.54 mm × 1.68 mm and is brownish black in colour.

Pupa: Each pupa measuring 5.4 ± 0.05 mm × 1.80 ± 0.06 mm, on an average is dull yellow and oval. The mouth parts, antennae, thoracic legs are well developed, while fore-wings and hind-wings start appearing on the third day. The mature pupa is black in colour and is found in the debris/soil underneath its host plant (Fig. 3).

Adult: The adult is 5.9 mm in length and 2.8 mm in width, metallic black in colour. Its filiform antennae have 11 segments, the second segment small, third and fourth about equal.

Mating: Mating is initiated 9–12 days following emergence from hibernating sites and lasts for 3–10 hours. Multiple mating throughout the active period of adult life-span is the normal behaviour pattern of the pest. The male positions himself on the posterior dorsum of the female at about an angle of 45° with the first pair of legs near the female's elytrae; the second pair of legs clasp the female about midway on the lateral margin of the elytra and the third pair of legs hold the terminal segments of female's abdomen. The male bends the tip of its abdomen down, extends and inserts the aedeagus into the female's vagina. The pair shows slow intermittant movement in a mated posture with the ♂ above the ♀ during the copulation period.

Oviposition: Eggs are laid singly and also in groups of 10–21 glued together on the ventral surface of the leaf. Most of the eggs were streaked with excrement. Mated female laid 45—60 eggs.

Hatching: The eggs hatch in 7—9 days. Before hatching, egg changes from yellow to greyish in colour. Hatching process takes about one hour. Within a cluster some eggs hatch at the same time. Almost all the eggs hatched and tiny, greyish larvae come out of the

TABLE 1. Summary of developmental stages of the life-cycle of *Altica caerula* Oliv.

Stages	Number of days		Measurements in mm		Appearance
	Range	Mean	Length mean (range)	Breadth mean (range)	
Egg to larva	7—9	8.0	1.12 ± 0.1 (1.06 – 1.20)	0.50 ± 0.12 (0.45 – 0.54)	yellowish oval
Larva to pupa	16—17				
First instar	3—4	3.6	1.23 ± 0.06 (1.20 – 1.28)	0.43 ± 0.1 (0.40 – 0.48)	creamy to grey
Second instar	5	5	3.48 ± 0.1 (3.44 – 3.51)	0.81 ± 0.08 (0.78 – 0.85)	grey to black
Third instar	8	8	5.13 ± 0.09 (5.10 – 5.15)	1.21 ± 0.1 (1.16 – 1.24)	grey to black
Pupa to adult	11—13	12	5.4 ± 0.05 (5.35 – 5.43)	1.80 ± 0.06 (1.74 – 1.82)	dull yellow, with blak eyes, turning black towards maturity
Adult			5.9 ± 0.1 (5.81 – 6.06)	2.8 ± 0.05 (2.75 – 2.9)	metallic black

chorion by rupturing it from its anterior side with the help of four hatching spines. Within 8—10 hours the larvae darken.

Feeding: Larvae start feeding within an hour after hatching. The first and the second instar larvae feed on the ventral epidermis and soft palisade tissue making a small hole while the third instar larvae feed voraciously on both sides of the leaf. Larvae respond quickly to tactile stimuli, but rarely move away while feeding. Larvae are leaf skeletonizers of their host plant. Both larvae and adults prefer young and tender foliage. Heavy populations resulted in defoliation of the host plant.

Ecdysis: The larval instars during the development undergo moulting. The first moulting occurs 3–4 days after hatching. When the second instar larva emerges from old skin it is evenly yellow in colour with sclerotized mouthparts only. For about one hour it shows no movement. Within 1–2 hours, it begins to feed again and start turning black. The second moult occurs within 5 days after the first moult. A third moult follows in 8 days, and initiates the beginning of pupation (Table 1).

Pupation: The larva stops feeding and becomes less active for about one day as it migrates from the host-plant into the debris lying underneath the plant in field conditions. In laboratory conditions, the pupation takes place in the sand placed in the glass vials. As pupation begins, the larval skin splits at the head and is shed from anterior to posterior end through longitudinal contractions and expansions. Pupa is slightly curled. Pupation lasts from 10–12 days.

DISCUSSION

Both the larvae and adults of *Altica* skeletonize the leaves of strawberries sometimes defoliating younger plants in Oregon as reported by ROSENTIEL & VAUGHAN (1952). GOEDEN (1952) referred to this species as *A. tombacina*. EDMUNDS (1965) studied the habits and life-history of *A. tombacina* infesting fireweed plant *Epilobium angustifolium* L. BARSTOW & GITTINS (1971) found *A. bimarginata* Say feeding selectively on foliage of *Salix exigua* and occasionally on species of willow, a wild rose and an evening primrose *(Oenothera* sp.). DE SWARTE & BALSBAUGH (1973) studied *A. subplicata* (LeConte) characteristically found feeding on *Salix interior* Rowlee. PHILLIPS (1977) while studying the biology and ecology of genus *Haltica* Geoff. in Britain found the beetle to feed on *Epilobium hirsutum* L. and *E. palustre* L.

FURTH (1980) recorded significant observations on the host-range of 7 species of *Altica* of Israel, where he has mentioned that this beetle attacks various economically important plants.

The pest under reference i.e., *Altica caerula* Oliv. completes its life-history in 34–39 days. However, *A. tombacina* completes its life-history in 26–34 days (EDMUNDS, 1965). Life history of *A. subplicata* is completed in 31–37 days (DESWARTE & BALSBAUGH, 1973). Life-cycle of *A. bicarinata* is completed in 6–7 weeks (FURTH, 1980) and this has three larval instars.

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BIONOMICS OF *ANOPHELES STEPHENSI* AND *ANOPHELES SUBPICTUS* (DIPTERA : CULICIDAE) ASSOCIATED WITH MALARIA

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During a period of 11 months (June 1982 to April 1983) larval, pupal and adult densities of *Anopheles stephensi* and *Anopheles subpictus* in relation to malaria transmission were recorded in Gurgaon city. Highest larval density (5.7 per dip) was recorded in August. Slide positive rate (7.1%) was highest in June. No *Anopheles stephensi* and *Anopheles subpictus* were captured in January and February. Highest incidence of *Plasmodium vivax* was recorded in June while *Plasmodium falciparum* was raported in November.

(Key words: density, *Anopheles stephensi*. *Anopheles subpictus)*

INTRODUCTION

In India, of all mosquito vector borne diseases, malaria is still the one which causes most concern to public health. *Anopheles stephensi* and *Anopheles subpictus* are urban malaria vectors in India (BATRA *et al.*, 1979). *Anopheles subpictus* has been incriminated as vector in South India (PANICKER *et al.*, 1981). *Anopheles subpictus* was found with sporozoites in Bastar district of Madhya Pradesh (KULKARNI, 1983). MENON & RAJGOPALAN (1979) studied the seasonal changes of *Anopheles stephensi* in Pondicherry. REHMAN & MENON (1975) studied the indoor resting places near Delhi. It was realized that field studies on the ecology of breeding places, larval and adult density of these vector species as related to malaria transmission and on the impact of the application of different larvicides were needed. In view of above, field studies were carried out over a 11 month period from June 1982 to April 1983 in Gurgaon city. The purpose was to determine immatures density, survival rate, and seasonal abundance of *Anopheles stephensi* and *Anopheles subpictus* and to relate this to malaria transmission. In addition, several promising larvicides were also applied in Gurgaon city.

Larval and pupal collections were made with the dipping methods. Adult mosquitoes were collected with aspirator tube and flash light spending 15 minutes per house from 6 AM to 8 AM. Sample of collected larvae and pupae were reared to the adult stage for identification since immature *Anopheles subpictus* and *Anopheles stephensi* cannot be readily distinguished from one another morphologically. The malaria *SPR* used in this study were those determined from both active and passive case detections. Annual parasite incidence, annual blood examination rate, slide positivity rate and slide falciparum rate were recorded from Gurgaon city (treated area) and Gurgaon rural (untreated

control area) to monitor the impact of *fenthion, abate, mosquito larvicidal oil* (MLO), *primiphosmethyl* and *pyrosine oil* (P. oil). MLO was used (1 lit/50 linear meters) in standing water where layer of the oil was possible and pyrosine oil 2 lit/500 linear meters) in breeding places with high organic pollution. Abate 50% EC (2.5 ml/500 linear meters) was used only in potable water while fenthion 1000 EC (5 ml/500 linear meters) and primiphosmethyl 50% EC (225 lit hectare) in grassy pits and ponds. Fenthion, abate, primiphosmethyl and p. oil were sprayed by knap sack sprayers. MLO was sprayed mop and bucket method. Quantity of emulsion concentrate required for each breeding site was calculated by measuring the actual breeding surface and diluted with required quantity potable water in the field. Epidemiological data were reported in larviciding and untreated control area from June 1982 to May 1983.

Larval and pupal densities of *A. stephensi* and *A. subpictus* along with their survival rate are given in Table 1. Seasonal adult density of *A stephensi* and *A. subpictus* are shown in Table 2. Table 3 shows the results of malaria incidence and consumption of different larvicides. During the period of 12 months (June 1982 to May 1983), annual parasite incidence (API), annual blood examination rate (ABER) and average slide positive rate (SPR) in larviciding and control area are given in Table 4. The highest larval density (5.7 per dip) was recorded in September 1982 while peak pupal density (3.3 per dip) was observed in November. The highest survival rate (42.9%) was recorded in October. Lowest survival rate was observed during winter season. SOEKIRNO *et al* (1983) and MENON

TABLE 1. Combined immatures density and survival rate of *Anopheles staphensi* and *Anophales subpictus*.

Month	No. dips	Density per dip		Survival rate %
		Larvae	pupae	
June, 82	1150	1.2	0.2	30.98
July	1300	1.5	0.5	37.31
August	700	5.7	1.1	32.12
September	950	3.6	0.8	40.99
October	1150	1.3	0.3	42.99
November	900	0.9	3.3	34.22
December	1400	0.5	0.1	22.26
January '83	950	nil	nil	nil
Feb.	1150	nil	nil	nil
March	1200	0.4	nil	3.63
April	1150	0 1	0.1	8.12

TABLE 2. Seasonal adult densities of *Anopheles stephensi* and *Anopheles subpictus* in relation to rainfall and slide positive rates.

Month	Rainfall (mm)	Density per man hour		SPR (%)
		A. stephensi	*A. subpictus*	
June, '82	82	4.8	5.6	7.2
July	114	5.6	3.2	4.5
Aug.	270.9	41.5	10.6	4.1
Sept.	5.8	15.8	10.7	4.1
Octo.	1	14 6	nil	2.1
Nov.	2	4.4	2.4	2.1
Dec.	7.5	2.6	nil	0.6
Jan., 83	32.5	nil	nil	0.7
Feb.	9	nil	nil	0.5
March	15	0.05	nil	0.4
April	149	1.3	nil	1.5

TABLE 3. Monthly consumption of larvicidence in relation to incidence of *Plasmodium vivax* and *Plasmodium falciparum*.

Month	Blood slides examined	*P. vivax*	*P. falci parum*	Larvicides (lit) MLO	fenthion	abate	p. oil	primipho-smethyl
June, 82	1066	76	nil	1410	14.115	1.215	43	nil
July	1044	47	nil	2120	18.215	1.685	81	nil
August	1667	70	nil	2245	16.715	1.595	nil	0.20
September	2274	93	1	1619	13.830	1.800	nil	0.305
October	1996	41	1	1536	14.625	1.990	nil	nil
November	1129	21	3	835	8.615	1.090	nil	nil
December	748	5	nil	575	9.975	0.885	nil	nil
January, 83	551	4	nil	685	4.325	2.865	nil	nil
February	917	5	nil	935	nil	1.500	nil	nil
March	992	3	1	1010	nil	2.420	nil	nil
April	666	10	nil	1250	nil	3.245	nil	nil

TABLE 4. Malariometric survey during larviciding and in control area from June '82 to May '83.

Parameter	Gurgaon city (larviciding area)	Gurgaon rural (control area)	% change
API*	3.5	5.5	+57.1
ABER**	12.6	12.5	−0.7
SPR***	2.7	3.6	+33.3

* API (per thousand population)
** ABER (per hundred population)
*** SPR (per hundred slides examined)

and RAJGOPALAN (1979) also observed the maximum larval density in September and October in BALI (Indonesia) and Pondicherry respectively. Among malaria vector identified in Gurgaon city studies, *A. stephensi* predominated in resting collections, followed by *A. subpictus* (Table 2). *A. stephensi* showed low prevalance in March and April and after that vector densities rose appreciably from June to October. The peak densities (10 7 per man-hour) for *A. subpictus* was recorded in September. *A. stephensi* and *A. subpictus* caught in different months showed overall higher density in August. ANSARI *et al.* (1982) also reported highest density for *A. subpictus* in August in Haryana state. Slide positive rates remained below 2.1% from December to April. Positivity rate were higher during June to September. Seasonal change in the density of mosquitoes collected followed consumption of different larvicides in relation to malaria cases are given in Table 3. *Plasmodium vivax* infection was common during the study with highest parasite number (93) in September. Out of 13048 blood slides examined from June 1982 to April 1983, 6 were positive for *Plasmodium falciparum*. Seasonal changes in adult densities of *A. stephensi* and *A. subpictus* were reflected in the monthly malaria slide

positive rate. In view of above results, it is clear from the present studies that the seasonal prevalance of malaria vector could be carried out accurately in the different localities of the city. In general, both larval and adult densities usually increased at the begining of June. The API decline occurred during larvicidal treatment followed by SPR over a 2.7% reduction in Gurgaon urban. Weekly application of these larvicides affected malaria incidence as well as seasonal increase in the immatures and adult vector densities. *A. subpictus* was recorded as malaria vector in South India (RUSSELL *et al.*, 1939). HARINAUSTA *et al.* (1976) regarding the vector in South-east Asia, *A. subpictus* has been mentioned as a recent vector in Indonesia. DAS *et al.* (1979) have shown that *A. stephensi* and *A. subpictus* infected with *Plasmodium vivax* and *Plasmodium falciparum* in Salem city.

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BIOEFFICACY OF THE CHITIN INHIBITOR SIR 8514 AGAINST THE RICE MOTH, *CORCYRA CEPHALONICA* STAINT

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The effect of SIR 8514 as a chitin inhibitor was studied on the immature stages of rice moth *Corcyra cephalonica* St. The first and third instar larvae were more susceptible than fifth instar larvae and the mortalities increased with higher concentrations. One day old pupae were more susceptible than three day old pupae.

(Key words: SIR 8514, *Corcyra cephalonica)*

INTRODUCTION

SIR 8514 has proved itself as chitin inhibitor in insects. CHARLES & EDWIN (1979) found it more effective in disrupting larval growth and development of various insect species. The present paper reports results of studies using SIR 8514 against the rice moth *Corcyra cephalonica* Staint.

MATERIALS AND METHODS

The test insect was reared in the laboratory. A randomised block design replicated thrice was adopted for the experiments. The desired concentrations of SIR 8514 were prepared by dilution with acetone.

To study the larvicidal activity, SIR 8514 treated maize flour was fed to the larvae in the first, third and fifth instars. About 100 g of maize flour was sterilized and was spread as a thin layer in a glass trough and 10 ml at the concentration of the toxicant sprayed uniformly on to the maize flour. The maize flour was air dried and 20 larvae of first, third and fifth instars introduced into it separately. The mortality counts were taken at the end of each of the test instars of the larvae. The maize flour treated with acetone served as control.

To study the pupicidal activity one day old and three day old pupae were dipped in different concentrations of the inhibitor for 10 seconds. They were then air dried and were kept in petri dishes and observed for adult emergence. The data obtaided on mean per cent mortalities were subjected to statistical analysis.

RESULTS AND DISCUSSION

Effect on larvae:

The treated larvae showed various types of deformities. Younger larvae were more susceptible than older larvae in terms of mortalities (Table 1). The mortalities ranged from 24.4 to 100 percent and 17.7 to 91.1 per cent in the first and third instar larvae respectively. In the fifth instar, except at the lowest concentration of 0.002 per cent, the mortalities recorded varied between 15.5 and 77.7 per cent. Higher concentrations showed higher effect in inhibiting the larval moults. The death of larvae was invariably connected with ecdysis. At lower doses larvae were able to cast off the old skin partly, but failed to complete the ecdysis and died. In some

TABLE 1. Effect of SIR 8514 on the larvae and pupae of *C. cephalonica* (per cent mortality).

Concentration of SIR 8514	1st instar larvae	3rd instar larvae	5th instar larvae	Early pupae	Late pupae
0·13%	100.0 (94.05)	91.1 (73.15)	77.7 (62.17)	100.0 (94.05)	70.0 (57.10)
0.065%	93.3 (75.58)	82.2 (65.42)	66.7 (55.06)	100.0 (94.05)	52.3 (47.18)
0.032%	84.4 (67.13)	68.8 (56.35)	53.3 (47.18)	90.0 (72.04)	40.0 (39.52)
0.016%	66.7 (55.06)	55.5 (50.77)	37.7 (38.17)	73.3 (59.12)	43.3 (29.20)
0.008%	53.3 (47.18)	44.4 (42.07)	28.9 (32.83)	56.7 (49.14)	13.3 (21.81)
0.004%	40.0 (39.52)	31.1 (34.20)	15.5 (23.58)	33.3 (35.55)	6.6 (15.45)
0.002%	24.4 (29.93)	17.7 (25.25)	0.0 (4.05)	16.7 (24.50)	0.0 (4 05)
Control (Acetone)	0.0 (4.05)	0.0 (4.05)	0.0 (4.05)	6.0 (4.05)	0.0 (4.05)
S ED	2.07	2.22	1.41	2.01	3.49
CD (0.05)*	4.45	4.77	3.01	4.31	7.49
CD (0.01)*	6.17	6.63	4.10	5.99	10.41

Figures given in parentheses are transformed values. * F test significant.

cases larvae were able to moult completely but remained inactive, immobile and died one or two days after ecdysis. Older larvae transformed into larval pupal intermediates. Similar results were reported by ASCHER *et al.* (1976) and HAMMAN (1980) in *Earias insulana* and *Laphygma fruginerda* respectively. SUNDARA MURTHY & SANTHANAKRISHNAN (1979) also observed similar effects in the last instar larvae of *Nephantis serinopa*.

Effects on pupae:

The mean percentage mortalities due to the treatment were higher in pupae one day old than those 3 day old. The adult emergence was completely inhibited at the higher concentrations of 0.13 and 0.065 per cent in one day old pupae. The mortality varied from 16.7 to 90 per cent in the remaining concentrations. In the three day old pupae, excepting at the lowest concentration of 0.002 per cent all other treatments were found to be lethal and the mean per cent mortalities varied from 6.6 to 70 per cent at 0.004 to 0.13 per cent concentrations.

The adults emerging out of treated pupae showed various degrees of morphological deformities. In the higher concentrations the adults failed to emerge completely from pupal case and at lower doses the newly emerged adults were crippled with underdeveloped wings. Similar findings were reported by RADWAN (1978), SUNDARA MURTHY (1977), SUNDARA MURTHY & SANTHANAKRISHNAN (1979) in case of *Pectinophora gossypiella*, *Spodoptera litura* and *Nephantis serinopa* respectively.

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PRELIMINARY STUDIES ON BIOLOGICAL CONTROL OF MOSQUITO LARVAE USING *BACILLUS THURINGIENSIS* AND *B. SPHAERICUS*

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Bacillus thuringiensis var. *israelensis* (Bti.) H-14 (VCRC B. 17), *Bacillus sphaericus* (Bsph.) (VCRC B. 64) and *Bacillus sphaericus* (Bsph) 1848 were tested against two species of mosquito larvae *Anopheles stephensi* and *Culex pipiens* in the laboratory. The 3 day grown crystals counted 10^8/ml; lower concentrations have been recorded as dose dependent potencies against 3rd instar mosquito larvae. The LC_{50} and LC_{90} determinations showed different degrees of species susceptibility. The strain *Bacillus sphaericus* 1848 was found to be most toxic to both the strains of mosquito larvae than other strains tested. The relative toxicities of the three strains are in the sequence, Bsph. 1848 > Bti. H-14 (VCRC B.17) > Bsph (VCRC B.64). The strains tested were found to be non-toxic to mammalian and other aquatic vertebrates. It is suggested that these strains could be used in aquatic environments to control the vectors and eventually vector borne diseases

(Key words: Bacillus thuringiensis var. *israelensis* (Bti), *Bacillus sphaericus* (Bsph), biological control, mosquitoes)

INTRODUCTION

There has been growing interest in developing alternate methods for chemical control of vectors as they leave residues and cause toxicity to non-target organisms. SINGER (1973) reported the isolation of several strains of *Bacillus sphaericus* which are highly toxic to *Culex pipiens* larvae. The bacterium *Bacillus thuringiensis* var. *israelensis* (Bti) shows immense promise as a mosquito control agent (COUCH, 1981; JAMBULINGAM *et al.*, 1984; THOMAS *et al.*, 1983). The bacterial pathogens Bti serotype H-14 and Bsph. were reported as effective against mosquito larvae under laboratory conditions (GOLDBERG *et al.*, 1977; SINGER, 1975; MULLIGAN *et al.*, 1978; SCHAEFER *et al.*, 1972 b; SCHNELL *et al.*, 1984) and the lethal concentrations were calculated. *Bacillus thuringiensis* var. *israelensis* has been found to be more effective against *Aedes* and *Culex* than *Anopheles* species (GOLDBERG, 1977; de BARJAC, 1978; de BARJAC & COZ, 1979). These and other investigations have determined the importance of species susceptibility, but few studies have examined other factors influencing the efficacy of these bacteria (SINGER, 1973; 1974).

The present study shows the variance in species susceptibility and bacterial strain efficacies in laboratory conditions. The bacterial strains used here were concluded as larvicidal and highly toxic to mosquito larvae.

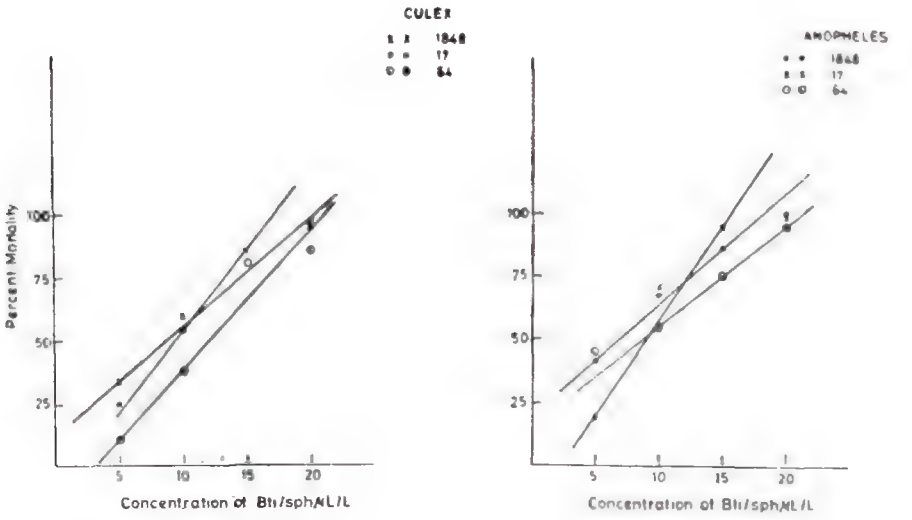
MATERIALS AND METHODS

Bacillus thuringiensis var. *israelensis* H-14 (VCRC B-17) and *Bacillus sphaericus* (VCRC-B-64) slant cultures obtained from Vector Control Research Centre, Pondicherry were maintained in nutrient agar medium and nutrient broths following the VCRC recommended procedures. A strain *Bacillus sphaericus* 1848 was obtained from Pasteur Institute, Paris. The 3 day grown crystal cultures were mixed with distilled water, and was approximately diluted to (10^4—10^8 ml) and the solutions were inoculated to one liter beakers containing 20, 3rd instar larvae of either species in each beaker and triplicates were run for each concentration. The mortalities were recorded after 24 h and 48 h of the treatments. The counts taken after 48 h are not included as the bacterial strains failed to produce high toxicity. However LC_{50} and LC_{90} values were calculated from the data colleced for 24 h treatments (Tables 1 & 2).

Nontarget organism toxicity studies were conducted following the method of Long Qingxin (1984). The safety tests were conducted for dermal and oral toxicity to Albino rats and mice, contact exposures to *Tilapia mossambica* and wild Guppies among fishes. The infected and dead mosquito larvae of both species were also fed to fishes along with fish food. Air was circulated through aerators. Five regular doses of 3 day nutrient broth grown cultures were used at 3×10^8 kg body weight. Each test was kept under observation for 15 days and the same were checked after a month.

RESULTS AND DISCUSSION

The strains of Bti. used to control the mosquito larvae showed remarkable response for their potential as larvicides. The LC_{50} and LC_{90} determinations for 24 h showed differential efficacies on different species of mosquito larvae. These results indicated the species susceptibility of the microbial larvicides (Figs. 1 & 2). The Bti. and Bsph. treated experiments were also observed for 48 h mortalities. But the efficacy of bacterial toxicity was depleted. This was also recorded by STEPHEN (1981, 1982). However the data collected for 24 h has shown LC_{50} and LC_{90} doses. The toxicity of 1848 strain is 0.124 times more potent on *Anopheles stephensi* than on *Culex pipiens* larvae. Similar observations were recorded with other bacterial strains



Figs. 1 and 2. Susceptibility of microbial larvicides to *Culex* and *Anopheles*.

TABLE 1. Relative toxicities and LC_{50}, LC_{90} concentrations *Culex pipiens* 3rd instar larvae when treated with three bacterial strains.

Name of the strain used.	Conc. UL/L	Counts bti/sph/ml	Regression equation.	LC_{50}	LC_{90}	Fiducial limits UL/L	Fiducial limits LL	Species susceptibility	Relative toxicity
1848	5–20	10^4-10^8	$y = -11.228+2.763\ x$	7.447 ±0.384	11.532 ± 0.342	8.895 13.458	6.285 9.885	1.12	1.124
VCRC 17	5–20	10^4-10^8	$y = -16.922+3.709\ x$	8.148 ±0.281	11.252 ± 0.264	9.252 12.681	7.175 9.985	1.09	1.230
VCRC 64	5–20	10^4-10^8	$y = -17.642+3.742\ x$	11.249 ±0.245	15.491 ±0.287	12.568 17.637	10.068 13.605	1.69	1.698

TABLE 2. Relative toxicities and LC_{50}, LC_{90} concentrations for *Anophels stephensi* 3rd instar larvae when treated with three bacterial strains.

Name of the strain used.	Conc. UL/L	Counts bti/sph/ml	Regression equation	LC_{50}	LC_{90}	Fiducial limits UL/L	Fiducial limits LL	Species susceptibility	Relative toxicity
1848	5–20	10^4-10^8	$y = -12.947+3.083\ x$	6.621 ±0.383	9.777 ±0.315	7.883 8.477	5.577 11.274	1.0	0.100
VCRC-H-14 17	5–20	10^4-10^8	$y = -26.000+5.280\ x$	7.449 ±0.223	9.345 ±0.206	8.237 10.258	6.735 8.513	1.0	1.125
VCRC 64	5–20	10^4-10^8	$y = -8.504+2.320\ x$	6.622 ±0.501	11.094 ±0.401	8.306 13.296	5.279 9.257	1.0	1.00

Bti. H-14 (VCRC B. 17) was more toxic than Bsph. (VCRC-B-64) the values being 0.105 and 0.698 respectively. Species susceptibility was almost equal for Bti. H-14 (VCRC-17) in two species of mosquito larvae. Bsph. serotype (VCRC B. 64) showed less toxicity than the other strains tested. Relative toxicities of the three strains are in order of its potency, Bsph. 1848 > Bti. H-14 (VCRC-17) > Bsph. (VCRC-64) (Tables 1 & 2). Similar species susceptibility and bacterial strain efficacies were recorded by GOLDBERG & MARGLIT (1977); SCHNELL *et al.* (1984); and SINGER (1973). Further the susceptibility of larvae was proportional to the concentration of Bti. and Bsph. used (Figs. 1 & 2). This could also be due to the fact that mosquito larvae are filter feeders and selectively concentrate on particles.

The dead mosquito larvae after 24 h treatment were examined to find out the site of action. The sites of attack were between the respiratory siphon and alimentary canal. The bacterial strains multiplied in alimentary canal and made their way to the head region. The strains of Bti. H-14 (VCRC B-17) and Bsph. 1848 were also found in the head regions of dead larvae. This explains the fact that the brain was severely affected by the bacteria which lead to immediate death. The α-exotoxin secreted by the bacteria delayed the pupal growth of the mosquito and deformity was shown by LARGET (1984). The α-toxins secreted by Bti. H-14 and Bti. serotype were reported by THOMAS (1983) for their mechanisms of action. The 3 day grown cultures were used to study the non-target organism toxicity. The dermal route of application did not show any toxicity to rats and mice. The shaven part of the rats were recorded with normal hair growth and the rats did not show any symptoms of itching or discomfort in their behaviour and food intake. The oral route treatments to rats affected the behaviour; it was observed that some disturbance and restlessness was recorded for an hour. After the initial setback the animals started to take food and there was no mortality during or after the observation period. The weights of the rats increased which represented their normal growth.

Fishes were tested for contact exposures, and infected larvae were fed to fishes; these did not show any lesions in the tissues for bacterial toxicity. Therefore it was concluded that these bacterial strains are safer to mammalian system and can be used as sprays in aquatic systems. Similar observations were recorded by QINGXIN *et al.* (1984), on fishes, rats and mice, SHADDUCK *et al.* (1980) on mammalian toxicity and ALI (1981) on aquatic non-target invertebrates. These studies recommend that the Bti. strains are safe to mammalian system and can control mosquito larvae without depleting the environmental grades.

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STUDIES ON ERIOPHYID MITES (ACARINA: ERIOPHYOIDEA) DESCRIPTION OF THREE NEW SPECIES FROM WEST BENGAL

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Three new species., *Disella oblongifoliae, Phyllocoptes shoreum* and *Vasates pavetis* infesting *Croton oblongifolia* Roxb., *Shorea robusta* Gaertn. and *Paveta* sp. respectively are described. The distribution, relationship and host plant association of these new species are also discussed

(Key words: Acarina, eriophyids, taxonomy, morphology, new species, India)

1. Disella oblongifoliae sp. nov. (Fig. 1)

Female: Body 133–175* long and 57–76 wide. Rostrum 22–27 long, projecting down; sub-apical seta 6–8 long. Shield semicircular 30–38 long and 45–50 wide; almost without any anterior shield lobe; shield design represents a number of distinct, continuous longitudinal lines; median line complete; admedians little sinuate and run almost parallel to median line; median connected with admedians on either side by three cross lines on 0.16, 0.3 and 0.66 part of shield from anterior margin; the cross line on 0.16 part is further extended laterally to meet lateral margin and that on 0.3 part extends for a short distanee receiving the first submedian where it divides into two lines: one meets the rear margin inside the dorsal tubercle and the other meets the rear margin outside the dorsal tubercles; many curved, indistinct and discontinuous longitudinal lines present specially on lateral and rear shield; dorsal tubercles placed well ahead of rear shield margin, dorsal seta 19–29 apart and 6–11 long, directing up and caudad. Forelegs 25–30 long from trochanter base; femur 6–8 long, granulated and with a seta 9–12 long; patella 4–6 long with a seta 21–26 long; tibiotarsus fused with setae, each 26–30 long; with a lower tarsal seta 7–9 long; claw 6 long, knobbed; feathferclaw 4–rayed. Hindlegs 23–26 long from trochanter base; femur 6 long and smooth, with seta 7–11 long; patella 4–5 long with a seta 16–21 long; tibiotarsus 6–8 long; claw 5–6 long; other characters as in the forelegs. Anterior coxae with a faint median suture; first coxal tubercles and seta absent; second coxal tubercles much ahead of the transverse line across third coxal tubercles; coxae ornamented with granules.

Abdomen with more or less equal number of tergites and sternites, without

[1] For Correspondence.

* All measurememts are in μ m unless otherwise stated.

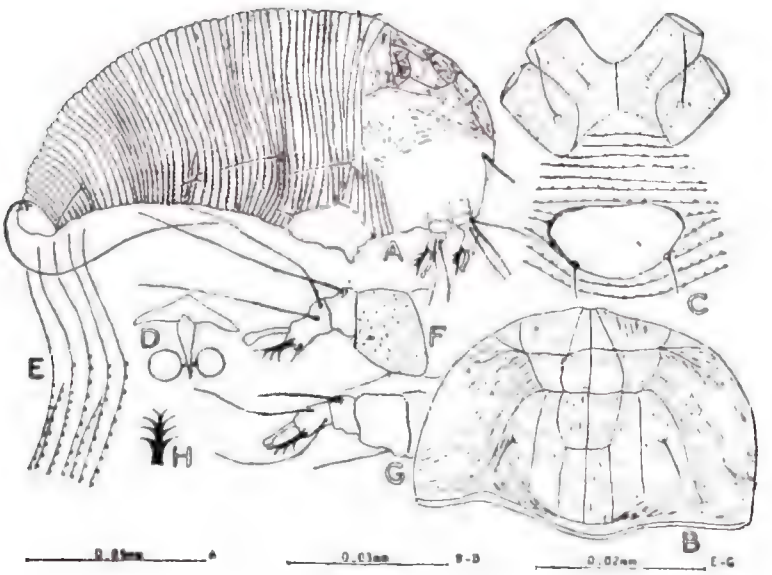

Fig. 1. *Disella oblongifoliae* sp. nov.

A : Lateral view of mite; B : Anterior dorsum of mite; C : Coxae with female genitalia; D : Lateral view of skin; E : Internal female genitalia (apodeme); F : Foreleg; G : Second leg; H : Featherclaw

any dorsal ridge or furrow; microtubercles present only on sternites as bead like structures and absent on tergites; lateral seta 18–24 long, on about sternite 6; first ventral seta 22–36 long, on about sternite 18; second ventral seta 6–8 long, on about sternite 33; third ventral seta 15–18 long, on about sternite 52; caudal seta 37–50 long; accessory seta 4–5 long. Genitalia 19–25 wide and 12–21 long; female genital coverflap smooth; genital seta 6–8 long.

Male: Unknown.

Holotype: ♀, INDIA : WEST BENGAL : Bankura, Dubrakone, 6. iv. 1980 from *Croton oblongifolia* Roxb. (Euphorbiaceae) on slide (No. 402/138/80), coll. B. Ghosh.

Paratypes: 15 ♀♀, on the holotypic slide and 56 ♀♀, on 10 slides (Nos. 403–413/80), collection data as in holotype; BIHAR : Santhalpargana, Massanjore, 12. i. 1981, from the same plant, 5 ♀♀, on 1 slide (No. 585/184/81), coll. A. K. DAS; additional material of this species have also been collected on 5. v. 1981, from *Croton oblongifolia*, Roxb., Bankura, Joypur forest and on 15. xii. 1981 from same and Bankura, Khulamuri forest.

Distribution: INDIA : BIHAR, West Bengal.

The mites are leaf vagrants on ventral surface of leaves. Due to heavy infestation discolouration and dark patches are seen on leaves.

Remarks: Having 4-rayed featherclaw, *Disella oblongifoliae* sp. nov. comes close to *D. talisiae* Keifer (1969) and *D. tectona* Das and Chakrabarti (1982).

In spite of that the present species *D. oblongifoliae* sp. nov. remains distinct from *talisiae* by ornamentation of shield and coxae, granulated femur, smooth genital coverflap, direction of dorsal setae (in *talisiae* shield, coxae and femur smooth, genital coverflap basally granulated) and from *tectona* by the ornamentation of shield, coxae, femur and genital coverflap and other characters in detail.

2. Phyllocoptes shoreum sp. nov. (Fig. 2)

Female: Body 165–180 long, 64–81 wide, fusiform and yellowish in colour. Rostrum 27–32 long, projecting down; subapical seta 4–5 long. Shield subtriangular with distinct anterior shield lobe, 43–47 long, 64–68 wide; shield design represented by some longitudinal and transverse lines; median line present only on posterior 0.33 part of shield; admedian lines complete and sinuate and connected with median line on either side of shield by two oblique lines posteriorly; submedian lines 3; first submedian runs parallel to admedian line backwardly and ends divergently ahead of dorsal tubercles; second submedian present only on anterior half of shield; third submedian arising from lateral shield margin runs backward and bifurcates slightly ahead of rear shield margin; inner fork meets the posterior end of first submedian an outer fork meets a transverse line which runs parallel to lateral shield margin and meets the admedian line on the middle part of shield; lateral shield with dotted lines; dorsal tubercles placed on rear shield margin, 36–39 apart from each other; dorsal setae 7–10 long, directed caudad convergently. Forelegs 34–38 long from trochanter base; femur 8–10 long, with a seta 5–7 long; patella 4–6 long, with a seta 18–23 long; tibia 5–6 long, with a seta 6 long; tarsus 5–7 long, with setae 10–14 long; claw 6 long and not knobbed; featherclaw 6-rayed.

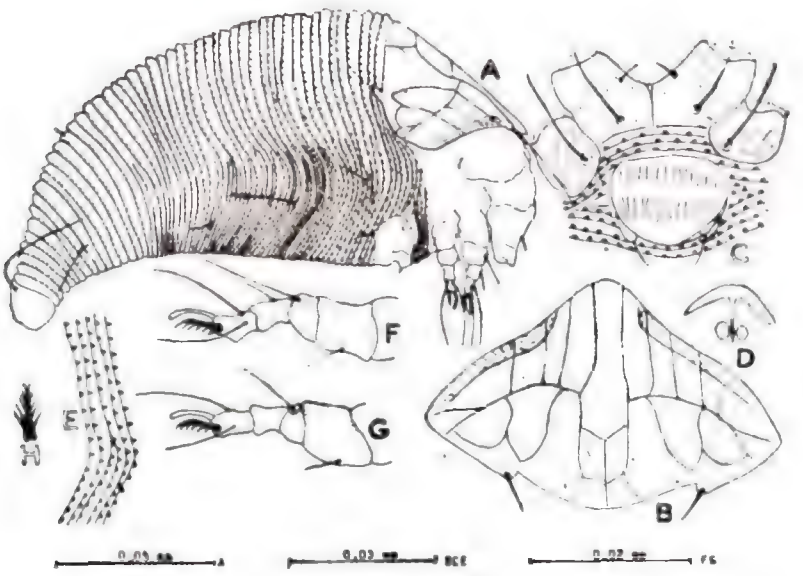

Fig. 2. *Phyllocoptes shoreum* sp. nov. For details see Fig. 1.

Hindlegs 27–30 long from trochanter base; patella 3–5 long, with a seta 15–19 long; tibia 4–6 long; tarsus 5–6 long, with setae 10–16 long; claw 5–6 long; anterior coxae contiguous, with distinct median suture; first coxal tubercles slightly ahead of the level of anterior coxal approximation; second coxal tubercles much ahead of the transverse line across the third coxal tubercles.

Abdomen with 48–52 moderately broad, evenly arched tergites and 55–65 narrow sternites. Both the tergites and sternites are microtuberculated. Microtubercules on tergites slightly elongated and on sternites rounded or elliptical and placed on the ring margin. Lateral seta 15–21 long, on about sternite 11; first ventral seta 15–20 long, on about sternite 25; second ventral seta 6–9 long, on about sternite 42; third ventral seta 15–21 long, on about sternite 11; first ventral seta 15–20 long, on about sternite 25; second ventral seta 6–9 long, on about sternite 42; third ventral seta 15–21 long, on about sternite 60; caudal seta 24–30 long; accessory seta absent. Genitalia 22–24 wide, 17–20 long, coverflap with longitudinal scorings in two tier, upper row with 14–15 and lower row with 16–17 scorings; genital seta 6–8 long.

Male: Unknown.

Holotype: ♀, INDIA : WEST BENGAL : Bankura, Dubrakone Forest, 1. i. 1980 from *Shorea robusta* Gaertn. (Dipterocarpaceae), on slide (No. 511/79/81), coll. B. Ghosh.

Paratypes: 9 ♀♀, on the holotypic slides and 72 ♀♀ on 7 slides (Nos. 512–518/79/80), collection data as in holotype. The same species have also further been collected on 30. iii. 1981 and 17. x. 1981 from same host and same locality.

Distribution: INDIA : WEST BENGAL.

The mites inhabit the ventral surface of leaves as vagrant without causing any apparent injury to the host plant.

Remarks: The nature of shield design, 6-rayed featherclaw and position of dorsal tubercles bring *Phyllocoptes shoreum* sp. nov. close to *Phyllocoptes chorites* Keifer (1972) and *Phyllocoptes scotti* Keifer (1940), but differs from both the species by the nature of genital coverflap, tergal microtuberculation and other characters in detail.

3. Vasates pavetis sp. nov. (Fig. 3)

Female : Body 142–190 long, 57–88 wide; funsiform pinkish brown in colour. Rostrum 21-30 long, projecting down; subapical seta 9-14 long. Shield semicircular 33–41 long, 52–63 wide; shield design with a number of longitudinal lines and lateral cells (4–5); median line complete; admedian lines complete but sinuate, run backward divergently upto 0.33 part from anterior lobe and then converging upto 0.66 part and finally meet the the rear shield margin divergently; three cross lines on 0.33 part, 0.66 part and 0.8 part connect the median line with admedian lines; cross lines on 0.33 and 0.66 part are further extended laterally parallel to lateral shield margin; submedian lines faint and 3–4 in number. Dorsal tubercles placed on rear shield margin, 22–33 apart from each other; dorsal setae 4–6 long directed caudad convergently. Forelegs 37–41 long from trochanter base; femur 7–9 long, with a seta 15–21 long, patella 3–5 long, with a seta 18–29 long; tibia 6–8 long, with a seta 9–15 long; tarsus 7–9 long, with setae 37–48 long; claw 6–9 long, without knob; featherclaw 5–rayed. Hindlegs 33–38 long from trochanter base; patella 3–5 long with a seta 10–15 long; tibia 6–8 long without seta; tarsus

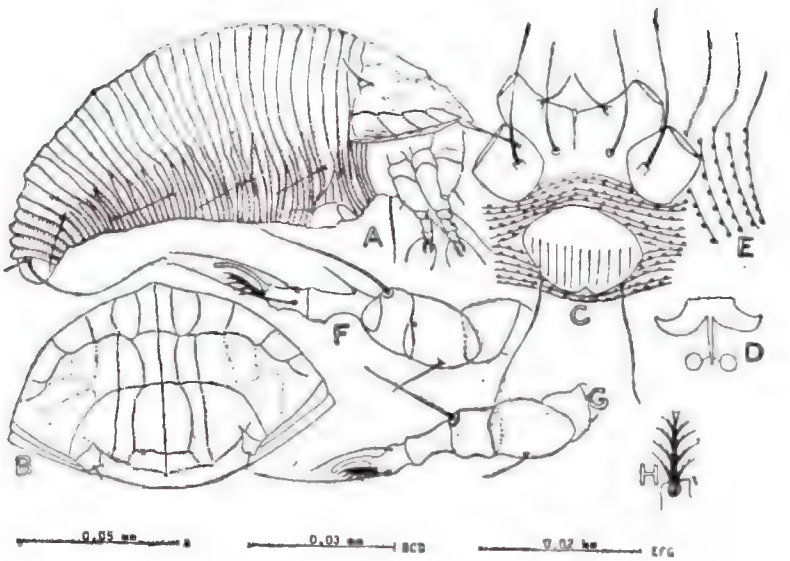

Fig. 3. *Vasates pavetis* sp. nov. For details, see Fig. 1

7–9 long; other characters as in forelegs. Anterior coxae contiguous with a distinct median suture; first coxal tubercles at the level of anterior coxal approximation; second coxal tubercles slightly ahead of the level of third coxal tubercles; both the coxae almost without any ornamentation.

Abdomen with about 33–38 broad, smooth tergites and 61–66 narrow microtuberculate sternites; microtubercles present on or nearer to the ring margin of sternite as bead like structure except a few telosomal sternites which are microstriated. Lateral seta 34–41 long, on about sternite 10; first ventral seta 27–38 long, on about sternite 23; second ventral seta 36–47 long, on about sternite 39; third ventral seta 27–39 long, on about sternite 58; caudal seta 40–58 long; accessory seta 4–7 long; genitalia 21–27 long; genitalia 21–26 wide, 19–27 long; genital coverflap with about 10–13 longitudinal scorings; genital seta 13–18 long.

Male : Unknown.

Holotype : ♀, INDIA : WEST BENGAL : Hooghly, Badanganj, 8.xi.1981, from *Paveta* sp. (Rubiaceae), on slide No. 442/148/81), coll. B. Ghosh.

Paratypes : 5 ♀♀, on the holotypic slide and 19 ♀♀, on 3 slides Nos. 443–445/148/81), collection data as in holotype; further material of this species have also been collected on 10.vi.1980 and 5.x 1980 from *Paveta* sp. Hooghly, Khalisani.

Distribution : INDIA WEST BENGAL.

This mite species are found on the ventral surface of leaves. No apparent damage symptom due to infestation was noticed during the period of collection.

Remarks: Presence of 5–rayed featherclaw of *Vasates pavetis* sp. nov. brings it very close to *Vasates celtidis*

Keifer (1957) and *Vasates pritchardi* Keifer (1953). However, the present new species remains distinct by its shield design in addition to other characters in detail.

All type meterials mentioned in this paper are deposited presently in the collection of Biosystematics Research Unit Department of Zoology, University of Kalyani, India, Kalyani - 741 235.

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RECORDS OF HITHERTO UNKNOWN SEXUALS OF TWO *MOLLITRICHOSIPHUM* (HOMOPTERA : APHIDIDAE) DESCRIBED FROM NORTH WEST HIMALAYA

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Descriptions of hitherto unknown alate oviparous females and males *Mollitrichosiphum (Metatrichosiphon) acutihirsutum* Maity and Chakrabarty and *M. (M.) alnifoliae* Chakrabarti and Raychaudhuri infesting *Alnus nepalensis* are provided.

(Key words: unknown sexuals, aphids, morphology, North West Himalaya)

Mollitrichosiphum (Metatrichosiphon) acutihirsutum Maity and Chakrabarti (1980) and *M. (M.) alnifoliae* Chakrabarti and Raychaudhuri (1978), the two greenideine aphids described from north west Himalaya are so far known by their apterous and alate viviparous females only. Recently discovered unknown alate oviparous females and alate males of these two aphids are described in this paper.

(Abbreviations used: b. d. III-basal diameter of antennal segment III; h.t.2-second joint of hind tarsus; p. t. - processus terminalis; u. r. s. - ultimate rostral segment).

Mollitrichosiphum (Metatrichosiphon) acutihirsutum Maity and Chakrabarti

Alate oviparous female: Body 2.42-2.47 mm long and 0.93-1.06 mm wide. Head with 26-28 hairs, longest anterior discal one 3.85-5.1 times the b. d. III. Processus terminalis 1.39-1.50 times the base of the segment VI and 0.32-0.35 times the segment III; segments I, II, III, IV & V with 5, 4, 39, 8 9 and 8-11 hairs respectively, longest and shortest hair on segment III 5.58-5.60 and 2.0-2.1 times the b. d. III respectively. Abdomen pale, spinulose, longest hair on anterior abdominal tergite 4.15-4.77 times, on 7th and 8th tergites 2.55-2.60 times and 3.71-3.87 times respectively the b. d. III. Siphunculi pale brown. Cauda with 8 hairs. Subgenital plate with numerous hairs. Hind tibia with 12-14 stridulatory ridges. Life colour green. Other characters as in alate viviparous female.

Measurement of one specimen in mm: Body length 2.42, width 0.93; antenna 1.84, flagellar segments III : IV : V : VI 0.72 : 0.24 : 0.26 : (0.17 + 0.24); u. r. s. 0.21; h. t. 2 0.12; siphunculus 1.64.

Alate male: Body 1.94 mm long and 0 65 mm wide. Dorsum of head with 32 hairs, longest anterior discal one 5.44 times the b. d. III. Antennae pale brown, 0.87 times the body length; segment III with 11-12 round secondary rhinaria and with 39 hairs, longest and shortest hairs

[1] For Correspondence.

on segment III 5 29 and 2 55 times the b. d. III respectively. Longest and shortest hairs on abdominal tergites 3 about 4 77 and 1.85 times the b. d. III respectively. Siphunculi pale yellow, 0.74 times the body, apical 0.06 portion spinulose. Clasper bifurcated, each with about 32-38 long and short hairs. Hind tibia with 10-13 stridulatory ridges. Other characters as in alate viviparous female.

Measurement of the specimen in mm: Body length 1 94, width 0 65; antenna 1.69, flagellar segments III : IV : V : VI 0.69 : 0.24 : 0.24 : (0.14 + 0.21); u. r. s. 0.17; h. t. 2 0.10; siphunculus 1.45.

Material examined: 2 apterous viviparous females, 14 alate oviparous females and nymphs, INDIA, UTTAR PRADESH, Almora, Omla, 13.x.1970 (Coll. S. Chakrabarti); 2 apterous viviparous females and nymphs, Lambagarh, 28.ix.1982 (coll. S. Saha); 2 apterous viviparous females, 2 alate oviparous females, 1 alate male and nymphs, Lambagarh, 28.ix.1982 (coll. P. K. Medda) from *Alnus nepalensis*.

Remarks: Chakrabarti and Maity (1978) reported 2 and 4 caudal hairs in the apterous and alate viviparous females which should be corrected as 8 caudal hairs.

Mollitrichosiphum (Metatrichosiphon) alnifoliae Chakrabarti and Raychaudhuri

Alate oviparous female: Body 2.0-2.35 mm long and 0.75-0.85 mm wide. Dorsum of head with 32 long hairs, longest anterior discal one 4.3 times the b. d. III. Antennae 0.65-0.80 times the body; p. t. 0.35-0.45 times the antennal segment III; segment III with 10-14 secondary rhinaria; segment I and II each with 5 hairs, segment III, IV and V with 28.30, 5-8 and 9-10 hairs respectively; longest hair on segment III 5.5-6.7 times the b. d. III. Ultimate rostral segment about 1.83-2.0 times the h. t. 2 and with 8 hairs. Anterior tergites with 16 hairs; longest and shortest hairs on tergite 3 about 3.0-3 5 and 2.0-2.5 times respectively the mentioned diameter; tergite 7 and 8 each with 2 hairs almost of equal length, 3 5-4.0 times the b. d. III. Siphunculi pale brown, 0.77-0 81 times the body, 15 9-16 6 times its maximum width, at base 3 02 times, at middle 2.0 times and at apex 1.51 times as thick as the middle diameter of the hind tibia. Subgenital plate with numerous hairs distributed in all directions. Hind tibia with 40-50 stridulatory ridges. Other characters as in alate viviparous female.

Measurement of one specimen in mm : Body length 2.28, width 0.84; antenna 1.5, flagellar segments III:IV:V:VI 0.60: 0.19:0.24: (0.17+0.24); u.r.s. 0.19; h.t.2 0.10; siphunculus 1.77.

Alate male: Body 1.60–1.95 mm long and 0.51–0.60 mm wide. Head pale brown with 12 hairs, longest anterior discal one 4.0–5.0 times the b.d.III. Antennae pale brown, flagellum gradually and distinctly imbricated apically, 0.9–1.15 times the body length, p.t. 1.10–1.15 and 0.39–0.48 times the base of segment VI and segment III respectively; segment III with 6–11 secondary rhinaria; longest hair on segment III 4.4–6 75 times the b.d.III. Ultimate rostral segment 1.65–1.85 times the h.t.2 and with 8 hairs. Abdomen pale; anterior tergites bear 16–18 hairs; longest hair on 3rd tergite 3.0–5.0 times the b.d.III; tergites 7 and 8 each with 2 hairs, longest on 2.45–4.3 times and 3.1-3.2 times the b.d.III respectively. Siphunculi pale brown, 0.80–0.95 times the body, 15.2–24.0 time the maximum width; at base 2.0 2.51 times at middle 1.51-2.0 times and at apex 1.0-1 5 times the

middle diameter of hind tibiae; apical 0.06 portion of siphunculi strongly spinulose. Cauda with 6-8 hairs. Clasper bifurcated each with about 34-40 long and short hairs. Hind tibia with 30-40 stridulatory ridges. Other characters as in alate viviparous female.

Measurement of one specimen in mm: Body length 1.92, width 0.60; antenna 1.85; flagellar segments III : IV : V : VI 0.67 : 0.26 : 0.30 : (0.21 + 0.26); u. r. s. 0.19; h. t. 2 0.10: siphunculus 1.68.

Material examined: 3 alate oviparous females, 1 alate male and nymphs, INDIA: UTTAR PRADESH, Almora, Lahrkhet, 11.x.1970(coll. S. Chakrabarti); 1 apterous viviparous female, 15 alate males and nymphs, Lambagarh, 28. ix. 1982 (coll. S. Saha); 2 alate viviparous females, 1 apterous viviparous female, 6 alate males and nymphs, Tapoban 30. ix. 1982 (coll. P. K. Medda); 2 apterous viviparous females, 6 alate oviparous females, 7 alate males and nymphs, Barkot, 7. x. 1982 (coll. S. Saha) from *Alnus nepalensis.*

Remark: For last several years, there developed a doubt about the separate entities of *Mollitrichosiphum (Metatrichosiphon) alni* Ghosh, Ghosh and Raychaudhuri (1970) and *Mollitrichosiphum (Metatrichosiphon) alnifoliae* Chakrabarti and Raychaudhuri (1978). However, from the available sexuals, it appears that in North west Himalaya the species is *alnifoliae* while in North east Himalaya it is *alni.* Males and oviparous females of *alnifoliae* differ from *alni* in having longer hairs on segment III (in *alni* 4.0 and 4.5-5.0 times respectively) and more stridulatory ridges (in *alni* 22-24 and 25-30 respectively) and in oviparous females short siphuncular length in relation to its maximum width (in *alni* 20-22 times).

Acknowledgements.—Acknowledgements are due to the Department of Science and Technology, Government of India for financing the work and to the Head of the Department of Zoology, University of Kalyani, for laboratory facilities.

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TWO NEW APHIDS (HOMOPTERA : APHIDIDAE) FORMING LEAF GALLS ON *PRUNUS* SPP.

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(Received 27 February 1985)

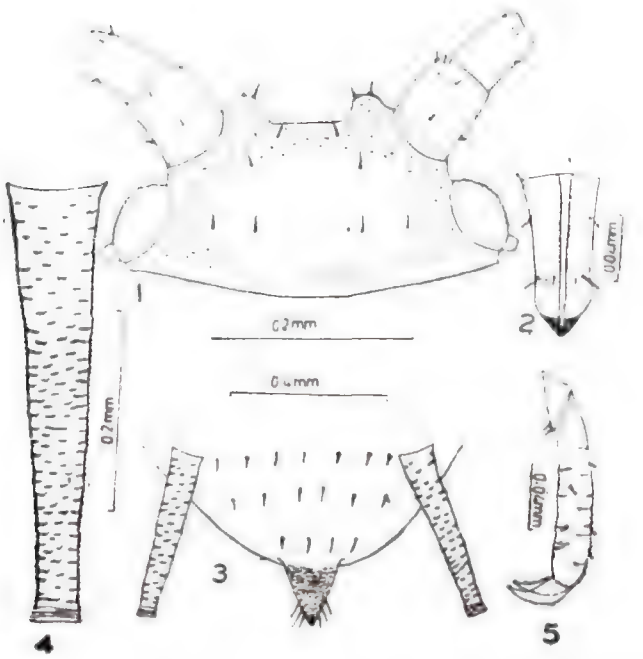
This paper encompasses the description of two new species viz., *Myzus cornutus* sp. nov. and *Eumyzus prunicolus* sp. nov. both from the plants, *Prunus* spp., in Garhwal and Kumaon regions respectively, of North West Himalaya. The nature of galls produced by these aphids have been described.

(Key words: aphids, taxonomy, aphid galls, new species, North West Himalaya, India)

Myzus cornutus sp. nov. (Figs. 1—8)

Apterous viviparous female (Figs. 1–5): Body pale, 1.96–2 47 mm long and 1 08–1 62 mm wide. Head pale, spinulose both dorsally and ventrally, dorsal spinules arranged leaving a free central area, with well developed diverging lateral frontal tubercles; dorsum with 6 pairs of hairs including 2 pairs on lateral frontal tubercles, with acuminate to myzine-type apices, longest one on vertex 20–54 μm long and 0.73–1.67 times the basal diameter of antennal segment III. Antennae 6–segmented, concolorous with body, 0.59–0.79 times the body; segments I and II scabrous with 6 and 4 hairs respectively, flagellum gradually and distinctly imbricated apicad; longest hair on segment III, 11–27 μm long and 0.38–0.88 times the basal diameter of the segment; processus terminalis 1.88–2.93 times the base of segment VI and 0.67–0.79 times the antennal segment III. Rostrum reaches midcoxae: ultimate rostral segment 0.87–0.93 times the second joint of hind tarsus and with 2 secondary hairs. Thorax somewhat scabrous, with 2 mesial hairs on prothorax; mid-thoracic furca either separated or jointed and sessile. Abdomen pale, little rugose, with lateral tubercles variably present on tergites 2–6; dorsal hairs variable in length with acute to acuminate apices; anterior tergites with 7–15 hairs; longest one on these tergites 25–58 μm long and 0.88–1.90 times the basal diameter of segment III; tergites 7 and 8 with 6 and 4 hairs, longest one on these tergites 25–63 μm and 32–59 μm long and 0.88–2 0 times and 1.13–1.93 times the basal diameter of segment III respectively. Siphunculi pale, long, subcylindrical, with coarse denticulate imbrications, moderately developed flange and few apical rows of transverse striae, 0.90–1.11 times the width of head across eyes, 0.17–0.23 times the body and 2.68–3.56 times as long as cauda. Cauda dusky, triangular, bearing 6 hairs, venter almost smooth; ventral hairs thinner than the dorsal hairs. Distance between 6th and 7th abdominal spiracles shorter than that between 5th and 6th. Subgenital plate with 2 hairs on anterior margin and 12–17

[1] For Correspondance.

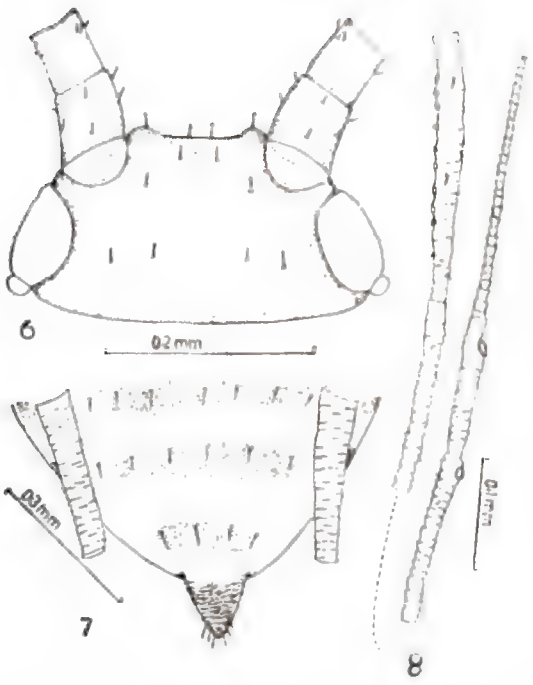


Figs. 1—5. *Myzus cornutus* sp. nov. Apterous viviparous female. 1. Head; 2. ultimate rostral segment; 3. posterior portion of abdomen; 4. siphunculus; 5. hind tarsus.

hairs on posterior margin. Legs pale brown, femora smooth except for distal end which show some scabrousity, tibiae smooth, tarsi sparsely imbricated. First tarsal chaetotaxy, 3 3.2. Nymphs with conspicuously spinulated hind tibiae.

Measurements of holotype in mm: Body length 1.96, width 1.08; antenna 1.54, antennal segments III: IV:V:VI 0.45:0.30: 0.21: (0.12+0.33); ultimate rostral seg- 0.11; second joint of hind tarsus 0.12; siphunculus 0.46; cauda 0.13.

Alate viviparous female (Figs. 6–8): Body 1.77–1.91 mm long and 0.72–0.94 mm wide. Head brown, almost smooth, with little scabrousness, with poorly developed diverging lateral frontal tubercles; dorsal hairs with fine apices, longest one on vertex 16–20 μm long and 0.6–0.85 times the basal diameter of antennal segment III. Antennae brown, 0.87–0.99 times the body; segment III with about 9–15 round protuberant secondary rhinaria distributed over the length except for the basal 0.10 and distal 0.30 portions, longest hair on segment III; 11–16 μm long and 0 40–0.64 times the basal diameter of the segment; processus terminalis 2.67–3.12 times the base of segment VI and 0.72–0 82 times the antennal segment III. Ultimate rostral segment 0.91–0.93 times the second joint of hind tarsus and with 2–3 secondary hairs. Abdominal tergites smooth and sclerotic, tergites 1–3 and 7 and 8 with separate brown spino–pleural sclerotic bands, tergites 4–6 with a fused spino–pleural sclerotic patch, marginal sclerites separately developed on tergites 2–7; lateral



Figs. 6—8. *Myzus cornutus* sp. nov. Alate viviparous female . 6. Head; 7. posterior portion of abdomen; 8. antennal segments (III–VI).

tubercles sometimes developed on segments 2–5; dorsal hairs short; fine and 6–8 per segment on anterior tergites, logest one on anterior tergites 16–20 μm long and 0.60–0.79 times the basal diameter of segment III; tergite 7 with 4–6 hairs, longest hairs on tergites 7th and 8th 20–27 μm and 27–31 μm long and 0.79–1.0 times and 1.0–1.23 times the basal diameter of segmet III respectively. Siphunculi brown, cylindrical with fine denticulate imbrications and poorly developed flange, 0.74–0.80 times the width of head across eyes, 0.15–0.18 times the body and 2.47–3.08 times as long as cauda. Cauda bearing 5–6 hairs. Subgenital plate with 2 hairs on anterior margin and 9–13 hairs on posterior margin. Legs brown, femora poorly scabrous on distal half. Wing venation normal; other characters as in apterous viviparous female.

Measurements of one specimen in mm: Body length 1.82, width 0.90; antenna 1.74, antennal segments III:IV:V:VI 0.51: 0.32:0.26: (0.13+0.39); ultimate rostral segment 0.10; second joint of hind tarsus 0.11; siphunculus 0.32; cauda 0.11.

Holotype: Apterous viviparous ♀, INDIA : UTTAR PRADESH : Bhuinder (Garhwal Himalaya), 7.vi.1983 from leaf galls of *Prunus cornuta* (coll. P. K. Medda). **Paratypes** : 25 apterous viviparous ♀♀, 25 alate viviparous ♀♀ and nymphs, collection data as in holotype; 32 apterous viviparous, ♀♀ and nymphs, INDIA : UTTAR PRADESH : Badrinath (Garhwal Himalaya), 26.v.1984 from leaf galls of *Prunus cornuta* (coll. P. K. Medda).

Remarks: Among *Myzus* species infesting *Prunus* spp., this new species shows its closest resemblances to *Myzus mumecola* (Matsumura) (in Takahashi, (1965). However, it can be separated from the latter species by shorter ultimate rostral segment compared to the second joint of hind tarsus in both apterae and alatae, presence of lateral tubercles on the abdomen and spiracles on 6th and 7th abdominal tergites being closer than on 5th and 6th ones in apterae, fewer secondary rhinaria in alatae and by spinulosity in hind tibiae of nymphs.

This species however, can also be separated from the so far known Oriental and Palaeartic species (Raychaudhuri *et al.*, 1980; Miyazaki, 1971; Takahashi, 1965) in having following combinations of characters; distance between 6th and 7th abdominal spiracles shorter than that between 5th and 6th, ultimate rostral segment shorter than second joint of

Photo 1. Infestation by *Myzus cornutus* sp. nov. on *Prunus cornuta*.

hind tarsus, siphunculi straight and uniformly imbricated and hind tibiae spinulose in nymphs.

Nature of gall (Photo. 1): The aphid infests the undersurface of leaves and causes ventrally rolled galls on either side of lamina. The infested leaves show rugose appearance on the dorsal side and during heavy attack, they turn yellowish.

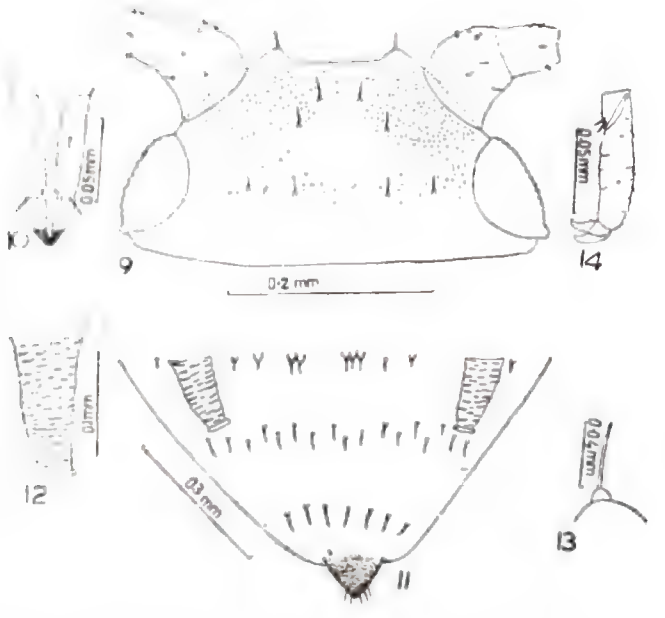
2. Eumyzus prunicolus sp. nov. (Figs. 9–17)

Fundatrix: Body 2.46 mm long and 1.86 mm wide. Head sparsely spinulose both dorsally and ventrally, with shallowly developed diverging lateral frontal tubercles; longest hair on vertex 20 μm long and 1.1 times the basal diameter of antennal segment III. Antennae 5-segmented, 0.25 times the body; segments I and II with 4 and 3 hairs respectively; longest hair on segment III, 11 μm long and 0.6 times the basal diameter of the segment; segment IV with a non-ciliated primary rhinarium whereas segment V with a ciliated one; processus terminalis 1.11 times the base of segment V and 0.45 times as long as antennal segment III. Ultimate rostral segment 0.89 times the second joint of hind tarsus. Mid-thoracic furca separate. Abdomen smooth, dorsal hairs short, mostly placed on low tuberculate bases; anterior tergites with about 24 hairs, longest one on these tergites 23 μm long and 1.3 basal diameter of segment III; longest hairs on tergites 7th and 8th 23 μm and 25 μm long and 1.3 times and 1.4 times the basal diameter of segment III respectively. Siphunculi very short, with fine denticulate imbrications and moderately developed flange, 0.24 times the width of head across eyes, 0.04 times the body and 1.25 times as long as cauda. Cauda helmet-shaped, bearing 4 hairs, subgenital plate with 2 hairs on anterior margin and with 14 hairs on posterior margin. Legs with smooth femora and tibiae. First tarsal chaetotaxy 2, 2, 2. Other characters as in apterous viviparous female.

Measurements of the specimen in mm: Body length 2.46, width 1.86; antenna 0.61, antennal segments III : IV : V 0.22:

0.10: (0.09 + 0.10); ultimate rostral segment 0.08; second joint of hind tarsus 0.09; siphunculus 0.10; cauda 0.08.

Apterous viviparous female (Figs. 9–14) Body pale, 1.81–2.04 mm long and 1.09–1.32 mm wide. Head pale, spinulose both dorsally and ventrally, dorsal spinules arranged leaving a free central area, with distinctly diverging lateral frontal tubercles; dorsum with 5 pairs of hairs including 1 pair on lateral frontal tubercles with acuminate apices, longest one on vertex 20–27 μm long and 0.79–1.0 times the basal diameter of antennal segment III. Antenna 6-segmented, concolorous with body, 0.48–0.57 times the body; segments I and II slightly scabrous, with 5–6 and 4 hairs; flagellum with segment III smooth and rest gradually imbricated apicad; longest hair on segment III, 13–16 μm long and 0.47–0.64 times the basal diameter of the segment; processus terminalis 2.7–3.22 times the base of segment VI and 0.80–0.90 times as long as antennal segment III. Rostrum reaches midcoxae; ultimate rostral segment 1.0–1.09 times the second joint of hind tarsus and with 2 secondary hairs. Thorax with many mesial hairs on prothorax; mid-thoracic furca sessile. Abdomen pale, dorsum little rugose anteriorly and finely spinulose posteriorly; dorsal hairs variable in length, on distinctly raised tuberculate bases upto tergite 6 and sometime spinally on tergite 7 and with fine to myzine-type apices; anterior tergites with 20–26 hairs, longest one on these tergites 28–34 μm long and 1.20–1.46 times the basal diameter of the segment III; tergites 7 and 8 with 16–20 and 6–8 hairs, longest one on these tegites 30–38 μm and 32–38 μm long and 1.21–1 54 times

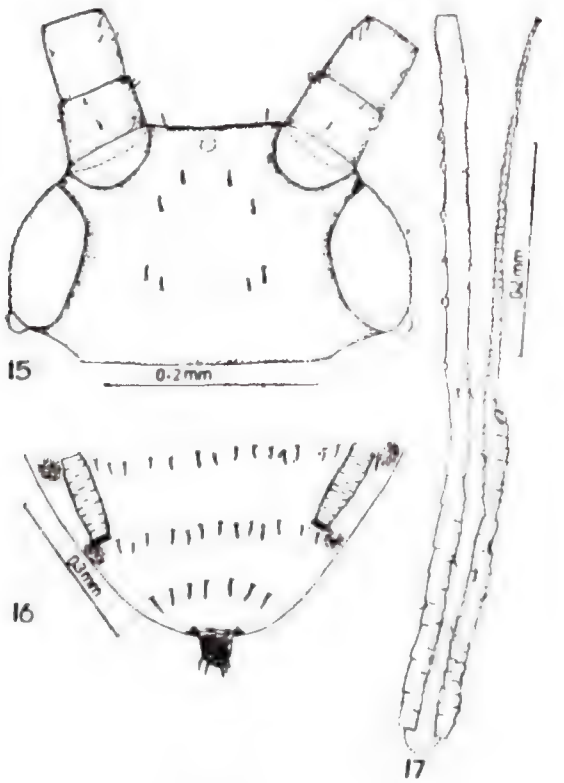


Figs. 9—14. *Eumyzus prunicolus* sp. nov. Apterous viviparous female; 9. Head; 10. ultimate rostral segment; 11. posterior portion of abdomen; 12 siphunculus; 13. dorsal hair on abdomen; 14. hind tarsus.

and 1.29–1.54 times the basal diameter of the segment III respectively. Siphunculi pale, short, subcylindrical, with fine to coarse denticulate imbrications and well developed flange, 0.30–0.35 times the width of head across eyes, 0.06–0 08 times the body and 1.33–2.0 times as long as cauda. Cauda dusky, short triangular to heart-shaped, bearing 5 hairs. Venter finely spinulose. Distance between 6th and 7th abdominal spiracles either as long as or longer than that between 5th and 6th. Subgenital plate with 3–5 hairs on anterior margin and 14–16 hairs on posterior margin. Legs pale brown, femora and tibiae poorly scabrous, tarsi poorly imbricated. First tarsal chaetotaxy 3,3,2. Nymphs with smooth hind tibiae.

Measurements of holotype in mm : Body length 2.0, width 1.26; antenna 1.0, antennal segments III:IV:V:VI 0.27:0.14 : 0.14: (0.08+0.24); ultimate rostral segment 0.1; second joint of hind tarsus 0.1 siphunculus 0.14; cauda 0.07.

Alate viviparous female (Figs. 15–17): Body 1.78–2.08mm long and 0.80–0.94mm wide. Head brown, smooth, with hardly developed lateral frontal tubercles; longhair on vertex 13–16 ^{u}m long and 0.58–0.75 times the basal diameter of antennal segment III. Antennae brown, 0.67–0.78 times the body; segment III with about



Figs. 15—17. *Eumyzus prunicolus* sp. nov. Alate viviparous female : 15. Head; 16. posterior portion of abdomen; 17. antennal segments III–VI.

9-8 round protuberant secondary rhinaria distributed over the length except for basal 0.10 portion and distal 0.30 portion, longest hair on segment III, 13–16 μm long and 0.54–0.75 times the basal diameter of the segment; processus terminalis 3.42–4.09 times the base of segment VI and 0.81–0.90 times as long as antennal segment III. Ultimate rostral segment 1.0–1.13 times the second joint of hind tarsus. Abdominal tergites smooth and sclerotic, dorsum with scattered sclerotic patches, those spinopleurally on tergites 3–5 form an interrupted patch, marginal sclerites separately developed on tergites 2–7; dorsal hairs short with acuminate apices and 20–24 per segment on anterior tergites, longest one on these tergites 18–27 μm long and 0 83–1.25 times the basal diameter of segment III; tergites 7 and 8 with 12–13 and 5–7 hairs, longest ones on these tergites 18–23 μm and 25–31 μm long and 0.03–1.08 times and 1.07–1.42 times the basal diameter of segment III respectively. Siphunculi brown, short, cylindrical, with fine spinular imbrications and moderately developed flange 0.37–0.42 times the width of head across eyes, 0 07–0.09 times the body and 2 0–2.62 times as long as cauda. Subgenital plate with 2 hairs on anterior margin and 10–11 hairs on posterior margin. Legs brown except for the basal 0.30 portion of femora, tibiae smooth. Wing venation normal. Other characters as in apterous viviparous female.

Measurement of one specimen in mm: Body length 1.98, width 0.8; antenna 1.43; antennal segments III : IV : V : VI 0.42 : 0.25 : 0.2: (0.1 + 0.34); ultimate rostral segment 0 09; second joint of hind tarsus 0.08; siphunculus 0.15; cauda 0.07.

Holotype: Apterous viviparous ♀, INDIA : UTTAR PRADESH : Khati (Kumaon Himalaya), 11. vi 1984 from leaf galls of *Prunus padus* (coll. A. K. Mandal). **Paratypes:** 32 apterous viviparous ♀♀, 14 alate viviparous ♀♀, 1 fundatrix and nymphs (coll. A. K. Mandal); 10 apterous viviparous ♀♀, 37 alate viviparous ♀♀ and nymphs (Coll. S. Chakrabarti), locality, date of collection and host plant as in holotype.

Remark: The genus *Eumyzus* has recently been reviewed by Chakrabarti and Bhattacharya (1985, in press). The present species is rather close to *E. gallicola* Takahashi (1963) in having prominent granules on head, a single hair on each dorsal tubercle on abdomen, in the ultimate rostral segment which is slightly longer than the basal part of antennal segment VI, in the ratio of processus terminalis and base of antennal segment VI in the apterae and in the ratio of ultimate rostral segment and second joint of hind tarsus and in the first tarsal chaetotaxy in alatae.

However, this new species differs from gallicola in having more prominently developed hair bearing tubercles, ultimate rostral segment as long as second joint of hind tarsus and bearing secondary hairs and tarsi with 3,3,2 hairs in the apterae and in having fewer secondary rhinaria and in the ratio of siphunculi to cauda in the alatae.

Nature of gall (Photo 2): Galls are formed either by ventral curling of the margins of the leaves or by emergence of catterpiller-like pouch galls on the dorsal side of lamina. In the former case, galled portion become somewhat shrunken, shortened and rugose on dorsal side while the latter one becomes thick,

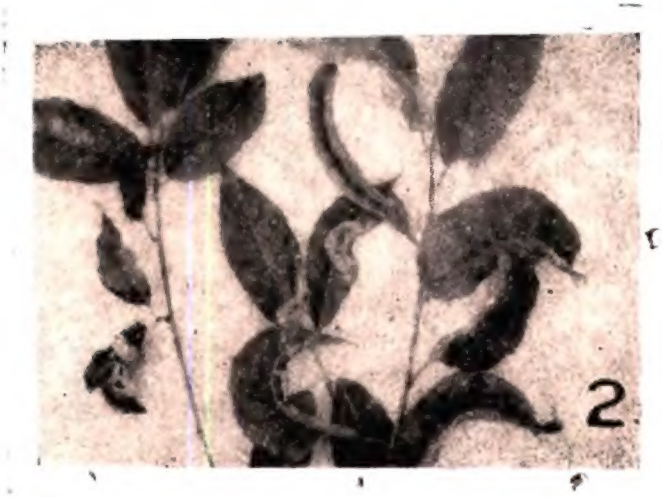


Photo 2. Infestation by *Eumyzus prunicolus* sp. nov. on *Prunus padus*.

rough and greenish to brownish in colour with a slit-like aperture on the ventral side.

Acknowledgement: The authors express their deep sense of gratitude to Dr. M. Miyazaki, Japan, for his comments on the identity of *Myzus cornutus* sp. nov., to the Head, Department of Zoology, University of Kalyani, for providing laboratory facilities, to the Department of Science and Technology, Government of India, New Delhi, for financial assistance.

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VII INTERNATIONAL CONGRESS OF ACAROLOGY, BANGALORE, INDIA

The VII International Congress of Acarology was held in Bangalore, India from August 3rd to 9th 1986, supported by the Indian Council of Agricultural Research, University of Agricultural Sciences, Bangalore, Acarological Society of India, the Indian Council of Medical Research, the Indian National Science Academy and the University Grants Commission. There were 157 delegates from 24 countries: Austria, Brazil, Bhutan, Canada, Czechoslovakia, Egypt, France, Federal Republic Germany, India, Iraq, Italy, Japan, Kenya, Nigeria, New Zealand, Poland, Sweden, Singapore, Switzerland, Tanzania, Thailand, The Netherlands, U. K. and U. S. A. The technical sessions were held in the West End Hotel. His Excellency the Governor of Karnataka inaugurated the Congress and Dr. M. V. Rao, Special Secretary, Government of India in the Department of Agricultural Research and Education presided. On this occasion a Souvenir was released by the Minister for Agriculture and Horticulture, Karnataka. An outstanding Acarologist, Dr. G. P. Channa Basavanna was honoured on this occasion by presenting an award entitled "Emeritus Acarologist" by the Acarological Society of India. Dr. G. P. Channa Basavanna, the President of this Congress was nominated an Honorary Member of the International Congresss of Acarology.

The deliberations of the Congress included three symposia on tropical acarology, tick ecology, and control and integrated management of mite pests of crops. Seven scientists were invited to present their points of view covering these areas. The presentations were followed by extensive and interesting discussions. In addition papers covering many aspects of Acarology were presented in 12 sections. Poster sessions were held on two days in the evening. The Congress concluded after the plenary session on 9th August.

It is planned to bring out the proceedings of the Congress containing the full papers covering the symposium topics and the twelve submitted paper sections and this is expected to be out during the later half of 1987.

B. K. NAGESHCHANDRA

ANNOUNCEMENT

THE APHIDOLOGICAL SOCIETY, India was established in 1979 as a professional society in order to promote research activities in the field of Aphidology. Those who are interested in aphid research (both in India and abroad) are welcome to be members of this Society. The Society publishes a half yearly News Letter. All members are eligible to get this free.

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